THE ENGINEER.

The Machine Tool Exhibition at Olympia.

The Machine Tool and Engineering Exhibition.

WE sincerely pity those poor mortals who are so tied up with their own or other people's affairs that they cannot spare even a single day spent among the galaxy of tools exhibited at Olympia. Here before the greedy eyes of those who would have their shops stocked with the most up-to-date machines is set forth a display, not to be repeated for another four years, of the best that British and foreign makers can produce. Our articles and our Supplements may be some consolation to those who cannot attend, but a sight of the tools themselves is better, it must be admitted, than many pages of description. Nevertheless, even to those who intend to visit the Show, our articles may be helpful in pointing out this or that interesting feature and in indicating where the most novel productions are to be found. It is with that intention that they have been written. Already we have found the capacity of two large Supplements too small to admit descriptions of all that there is to see, and in this issue and others to follow we intend to continue our remarks.

H. W. KEARNS AND CO., LTD.

Of the three boring machines on the stand of H. W. Kearns and Co., Ltd., Broadheath, near Manchester, we have chosen the new No. 4 size, shown in Fig. 1, for illustration. Its novelty lies largely in the fact that it has been designed to take the fullest advantage of the cutting powers of modern high-speed steel tools, and consequently is of very sound and robust construction—a fact which is plainly visible in our illustration.

In this machine, like others by the same makers, the boring spindle and the facing chuck can be worked together, or independently, and the spindle can be advanced into the work quite separately from the movement of the table. The operator thus has a much more sensitive control of, for instance, a boring operation than if the mass of the table and work had to be moved towards the tool. The spindle of this machine is intended to run at speeds ranging from 2 to 168 revolutions per minute in twenty-four steps, and is consequently driven directly by belt for the higher speeds, while the lower speeds are obtained by means of spur gearing. The gears, it will be seen, are enclosed in a box which has a clean appearance and helps towards efficient lubrication. There is a range of eight boring feeds from 8 to 96 cuts per inch, with a corresponding number of milling feeds from 0·8in. to 10in. per minute, both of which are directly interconnected with the spindle. The spindle slides in a hardened steel bush, which runs in an adjustable phosphor bronze bearing, so that the spindle is free from all wear that might be caused by revolving in bearings. The facing chuck is carried by a forged steel sleeve which runs in parallel bearings that are of ample length, yet keep the final drive as close to the cutting tool as is possible. An automatic feed for the tool, in either direction, is obtained from the main feed box. The table has a cross traverse besides the end movement along the bed and on the top of it there is mounted a square turn-table, which can be rotated and locked exactly at every 90 deg. Intermediate angles can naturally be secured by ordinary clamps. All the motions for both the spindle head and the table are provided with rapid power traverses in each direction. The machine has a spindle 4in. in diameter, which has a rise and fall of 30in., while the main table measures 66in. by 42in. The maximum length of job between the facing slide and the boring stay is 7ft. 9in. About 15 H.P. is required to drive the machine.

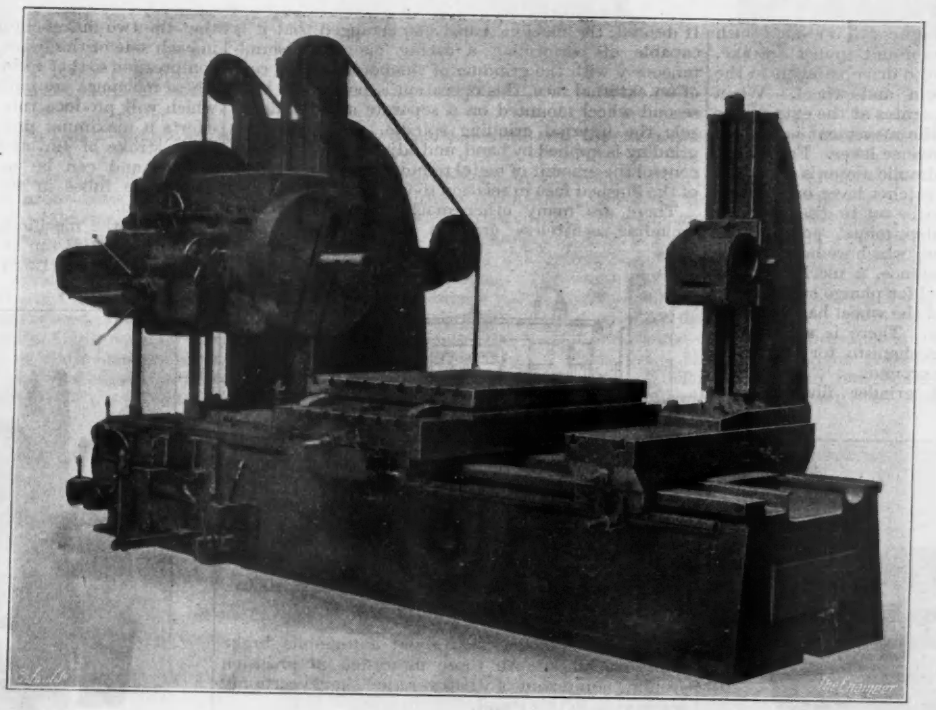


FIG. 1—SURFACING AND BORING MACHINE—KEARNS

MOND NICKEL COMPANY, LTD.

Although in the past steady progress has been made in the design of machine tools, less attention has been given to materials of construction, and it is only comparatively recently that progressive manufacturers have begun to avail themselves of the improved properties offered by alloy steels and the newer alloy cast irons. The exhibit of the Mond Nickel Company, Ltd., of Thames House, Millbank, London, is intended to demonstrate how nickel alloy steels, nickel cast irons, and other nickel alloys are being utilised in machine tool construction to meet present-day conditions. It includes a panel containing particulars of the materials recommended for different components of machine tools, and for small tools, dies, &c., illuminated diagrams of a lathe, drilling machine, and miscellaneous components illustrating the applications of these materials, together with actual exhibits of some of the parts. Chief among the latter are a lathe bed, rest plates, &c., in nickel cast iron, and such items as press dies, gears, drill chucks, and chisels in nickel alloy steel.

THE CHURCHILL MACHINE TOOL COMPANY, LTD.

A large number of grinding machines of many differing types are exhibited by the Churchill Machine Tool Company, Ltd., of Broadheath, near Manchester. On this firm's stand there is to be seen one of the most interesting of the many developments in grinding machine design which have taken place in recent years. We refer to what the firm terms the "Hydrauto" head. It is a commonplace to say that the quality of the work produced by a grinder and the lasting properties of the wheel depend upon the steady running of the wheel spindle. It is upon the design of the wheel spindle that the manufacturer devotes the greatest care if he wishes his reputation to remain a high one. Unfortunately, from the point of view of vibrationless running, it is next to impossible, if not actually so, to design an ordinary bearing which is an excellent fit, both cold and warm. Necessarily, the adjustment must be such that the spindle will rotate freely and oil circulate for adequate lubrication when the wheel head is cold. It follows, therefore, that after a period of running, when the proper running temperature is reached, there is a slight looseness of the spindle in the bearings, not only as a result of expansion, but also owing to the fact that the viscosity of the oil has been lowered. The change is insufficient appreciably to affect the accuracy of the machine, but, owing to the fact that it may allow vibration to occur, it is detrimental to the finish obtained on the work and to the lasting properties of the wheel.

The problem of designing a bearing which will overcome such troubles appears to have been very neatly solved by the Churchill Machine Tool Company, Ltd. In the grinding head illustrated by Fig. 4, hydraulic pressure holds the top half of the spindle bearing in contact with the spindle. The arrangement is shown sectionally in Fig. 5. The wheel head, as heretofore, consists of a rigid casting giving ample support to the bearings. The spindle itself is made of Nitralloy, and it runs in split bronze bearings, the lower halves of which are carried in the wheel head casting. But the upper halves of the bearings are not bolted down. The upper bearing cover is made with an internal chamber into which lubricating oil is introduced under pressure. This oil acts upon pistons which bear upon the top halves of the bearings. The lubricating oil pump maintains the pressure in the "piston" chamber. By this means the spindle clearance in the bearing at the running temperature can be automatically reduced to very fine proportions, and thus the hardly perceptible vibration of the wheel can be eliminated.

Many Churchill grinding machines were described in a series of articles appearing in THE ENGINEER during the latter half of 1932. But although those articles covered the general features of the machines built by the firm, improvements are constantly being made in detail, and we, therefore, think it permissible to mention one or two of the more interesting grinders to be seen on the stand. The plain cylindrical grinding machine illustrated in Fig. 2 is fitted with the "Hydrauto" spindle bearings already described. It is suitable either for traverse or plunge cut working. The spindle, which is mounted in a wheel head of box form design, giving a low height over the inverted vee slides, is driven by multiple vee belts from an electric motor at the back. As everyone knows, a rigid design of bed is a necessity for a grinding machine, and the structure manufactured by the firm is of the three-point support type, which avoids the possibility of distortion if unevenly mounted. The work traverse is operated hydraulically and controlled to give any speed between 6in. and 240in. per minute by the rotation of a small thumb wheel. Trip dogs carried on a rack at the front edge of the

table adjust the stroke length, and the arrangement is such that, if required, the table can be run past the position set by the dogs without disturbing their location. This refinement is particularly useful when it becomes necessary to bring the trimming diamond into action. The work is rotated by a variable-speed motor driven from a generator mounted on the back of the bed, and any desired speed can be obtained within the extremities of the range. A push button starts the work head rotation and a thumb wheel regulates its speed. When depressed, a second push button stops the work rotation and applies a brake. From the work head motor the drive is taken to the work head through a worm and wheel. When traverse grinding the feed operates at the extremities of the traverse stroke and the movement is derived from the trip over of the traverse lever. For plunge cut grinding an auxiliary hydraulic motor is employed and is used to oscillate the ratchet lever on the feed disc. If required, a trip can be set to disengage the automatic feed at a predetermined point. The machine has many refinements which we have not the space to mention. For instance, a mechanism for oscillating the grinding wheel for plunge cut grinding can be fitted. Oscillation of the wheel has the effect of preventing uneven wear. There is a hydraulic quick wheel withdrawal mechanism for use when varying diameters are to be ground.

The automatic internal grinder illustrated in Fig. 3 is an interesting tool. Insertion and removal of the work are the only operations manually performed once the machine has been set up and started. It operates on the plunge cut principle, and is intended for use on bores the length of which is not more than twice the diameter and does not exceed 2in. It is claimed that a given size of bore can be repeated an indefinite number of times to an accuracy within 0·0002in. When the lever is moved to start the cycle of operations the work head advances rapidly towards the grinding wheel and the wheel guard lifts; the trimming device falls into the operating position and the table speed is automatically retarded to that suitable for truing; after the wheel has been dressed the trimming device lifts clear of the work and the work head oscillation and grinding wheel feeds come into operation; when the bore has been ground to size the work head is rapidly run out and simultaneously the wheel guard lowers itself over the wheel; lastly, all motions stop except rotation of the grinding wheel, and the operator inserts a new work piece. When grinding, the movement of the table is a short high-speed oscillation adjustable up to a maximum of ½in. for length of movement. The feed is applied by a cam which gives a high rate of metal removal at first and a slow rate as the correct diameter of the bore is approached. In this way a high quality finish is obtained. Coarse adjustment for taper grinding is made by swivelling the work head, on the sub-base, whilst for the final setting the latter is moved by means of a fine screw and nut mechanism. If desired, the machine can be so arranged that it is capable of performing a facing operation simultaneously with the grinding of the bore. In the case of an external face, this operation is performed by a second wheel mounted on a separate spindle alongside the internal grinding spindle. Feed for face grinding is applied by hand, and adjustable dead stops control the amount of metal removed and the position of the finished face in relation to the bore.

There are many other machines on the stand, including centreless grinders and special-purpose tools, such as spline shaft, and automobile brake drum machines. All those interested in precision grinding equipment of whatever kind should certainly pay a visit to this stand.

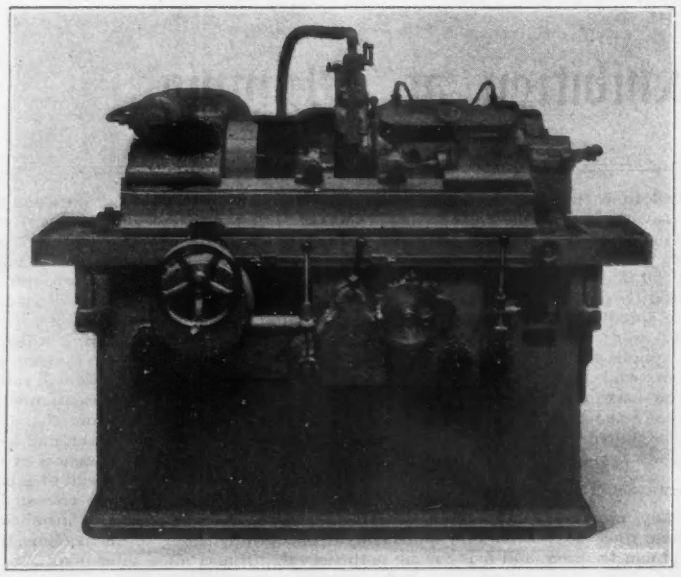


FIG. 2—CYLINDRICAL GRINDER—CHURCHILL

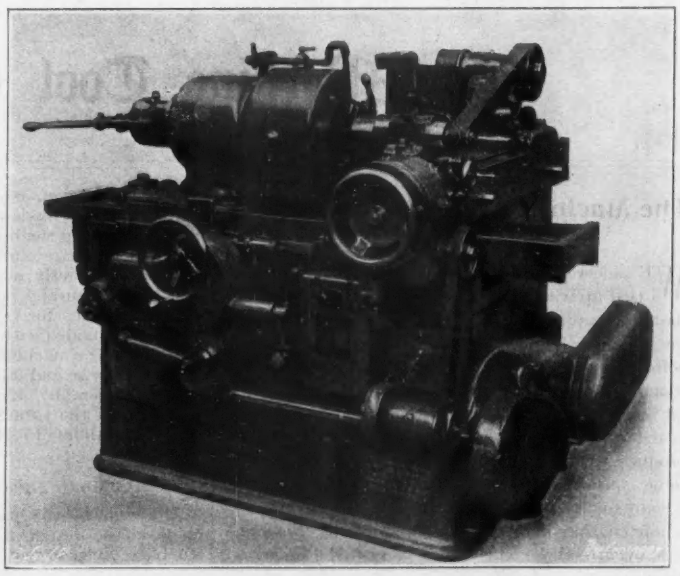


FIG. 3—AUTOMATIC INTERNAL GRINDER—CHURCHILL

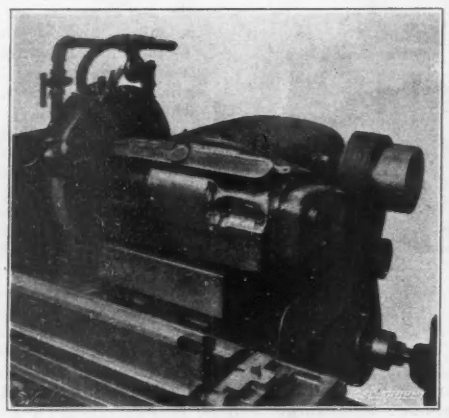


FIG. 4—"HYDRAUTO" GRINDING HEAD—CHURCHILL

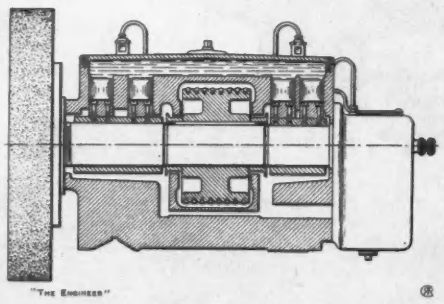


FIG. 5—SECTION THROUGH "HYDRAUTO" HEAD—CHURCHILL

GREENWOOD AND BATLEY, LTD.

There are many interesting machines on the stand taken by Greenwood and Batley, Ltd., of Leeds. A double-stroke cold forging machine is producing ⅜in. B.S.F. cheese-head bolt blanks with 1¾in. shanks, from a coil of 0·375in. diameter steel wire, 30/35 tons tensile strength at the rate of sixty per minute. Working in conjunction with this machine there is an automatic bolt head trimming machine, which trims the blanks produced to ⅜ B.S.F. hexagon heads at the rate of seventy to eighty per minute. The work, as indeed might be inferred from the rate of operation, is carried out entirely automatically. The blanks are placed in a hopper and conveyed through the machine without further handling. Another interesting exhibit is a $\frac{3}{16}$in. automatic screw thread rolling machine producing $\frac{3}{16}$in. Whitworth button-head screws.

A 1in. vertical lead tube extruding press attracts attention. It is illustrated in Fig. 6. Its slide is operated by means of a toggle mechanism from a crank shaft at the back of the frame, and the drive is by belt through single reduction gearing. An automatic clutch is fitted and it allows only one stroke of the slide to occur at a time. The slide is stopped in the bottom position at the end of each stroke. Safety operating levers ensure that both the operator's hands are out of danger when the press is started. The extruding punch is carried in a swinging block anchored to the top of the main frame and is operated by a cam on the crank shaft, which allows the punch to swing out to an angular position to the front when the slide carrying the die is at the bottom position. On the upward stroke of the slide the punch is brought to the vertical position by springs and, the punch being offset from the centre line of the machine, it remains perfectly vertical during the extrusion process. The extrusion die is carried on top of the slide and is arranged in a bolster plate with adjusting screws for setting purposes. It is interesting to note that the two nickel-chrome steel tie bolts are shrunk in each side of the frame, which is thereby put under compression so that springing while at work is avoided. These machines are built in four sizes, the largest of which will produce tubes up to 3½in. diameter and exerts a maximum pressure of 300 tons. It has a table stroke of 4in. and will give twenty strokes a minute and can be used for the manufacture of collapsible tubes in tin, tin-covered lead, lead, or aluminium.

Besides the machines mentioned the firm is also exhibiting a 2/2½-ton elevating platform petrol truck driven by a Morris 12/25 H.P. engine, and a number of details demonstrating the methods of manufacture and construction of variable-speed hydraulic pumps.

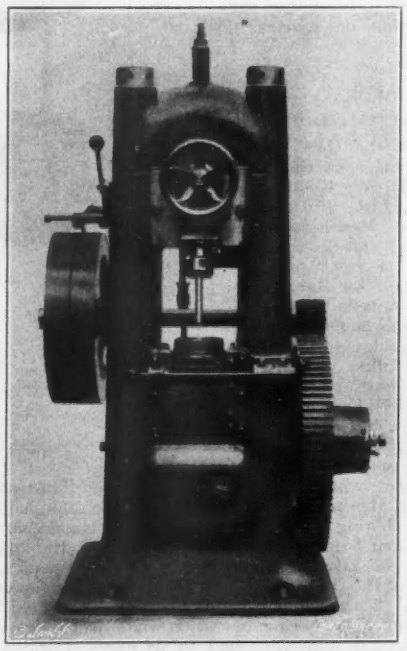


FIG. 6—LEAD TUBE EXTRUDING PRESS—GREENWOOD AND BATLEY

GASTON E. MARBAIX, LTD.

Those interested in the production of gears should certainly pay a visit to the stand of Gaston E. Marbaix, Ltd., of Vincent House, Vincent-square, London, if only to see in what manner an American firm can tackle the job. There is to be seen on this stand a production unit of four machines all manufactured by the Michigan Tool Company, of Detroit, and representing the latest American practice in the production, finishing, and testing of helical gears. Three of these machines are illustrated by the

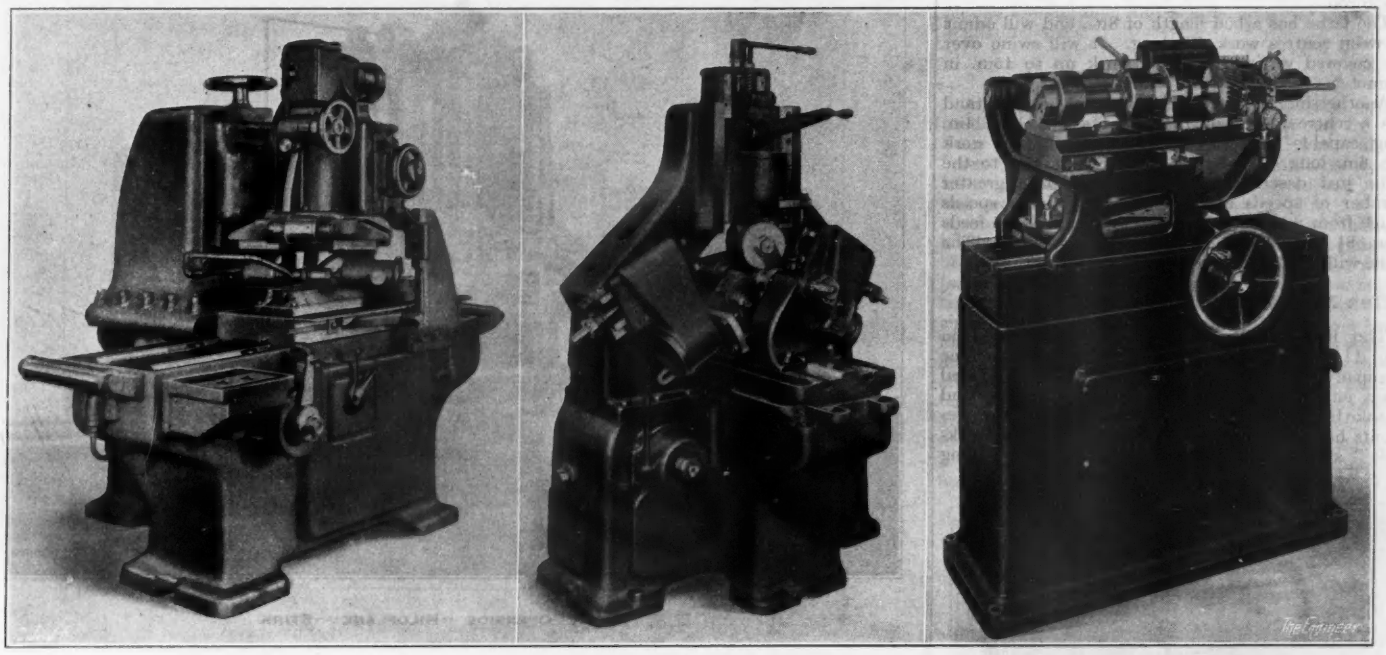
engravings, Figs. 7, 8, and 9, and we do not intend to describe them in detail, since the main principle of each will be made clear by examination of the engravings. The first illustration—Fig. 7—shows a gear-finishing machine for use before heat-treatment of the gear is carried out. It is claimed that the method employed gives more rapid production than any other, while at the same time finishing to such limits of concentricity, form, and spacing that 85 to 95 per cent. bearing across the full face of the gear tooth can be guaranteed. The teeth are finished against a horizontal cutting rack, the situation of which is clearly to be seen in the engraving. The work is fed on to it by a hydraulically controlled head in which it is mounted on an arbor between centres. Two arbors are used, so that while one gear is being finished another, rough cut, will be loaded on to the other arbor by the operator. Production thus becomes continuous. The work travels a predetermined number of strokes (from 1 to 50) across the rack, and the head is then raised automatically. Cutting racks for this machine are built up of serrated segments, and by a system of photo-electric inspection it is claimed that they are maintained accurate to within 0·000025in. Since each rack can be re-ground to accuracy about twenty to twenty-five times, an output of over 150,000 gears can be expected from each rack during its useful life. The machine is driven by a 5 H.P. motor and will accommodate gears from 2in. diameter, ½in. face, up to 8in. diameter by 2in. face. According to the makers, this machine, operating on a 28-tooth, 10-pitch gear, with 40 deg. pressure angle and ½in. face, can remove 0·004in. to 0·008in. stock at a production rate of eighty pieces per hour, and give limits of accuracy of 0·0015in. excentricity, 0·0002in. on involute, 0·0002 per inch on the helix angle, and 0·0002in. on the tooth spacing.

The following illustration, Fig. 8, shows the lapping machine which is used after the gears have been heat treated. Three laps are used, each of which has an individual brake action. Each lap can be set at a different amount of crossed axis to effect a different lapping condition, and its extent can be controlled by the brake. Alternatively, all the laps may be set exactly the same and synchronised by an adjustable reciprocation. Each lap can be adjusted for centre distance so that if and when it is re-cut it may still be used again on the same size of gear. The rotation in each direction can be varied in half-minute cycles, so that it is possible, for instance, to have ½-minute operation on the back side and 2½-minute operation on the driving side per cycle. It is claimed that the use of three lapping spindles in this manner reduces spacing errors besides speeding up production. Hydraulic braking is employed on all three spindles, and the upper slide may be raised or lowered to facilitate loading and unloading the machine. Once set up the operation of the machine is almost entirely automatic. The time cycle for lapping the driving and back sides of the teeth is predetermined from a control base. With gears of 10 pitch and 3in. pitch diameter an output of twenty gears per hour is obtainable. A 3 H.P. motor drives the machine through a texrope and gears between ½in. and 13in. diameter and up to a face width of 2½in. can be accommodated.

To follow the lapping machine there are two machines for checking the accuracy of the product. The involute checking machine, which we do not illustrate, employs the sine-bar principle. The function of the sine-bar is to act as a compensator for a difference between the length of arc of 1 deg. on a friction disc which originates all the machine movements, and the length of arc of 1 deg. on the base circle of the gear being checked. The friction disc is integral with the work-holding spindle, and imparts movement to the sine-bar carriage, alongside which there is a scale registering each degree of rotation of the work. The angular setting of the sine-bar controls the movement of the indicator head, which moves at right angles to it. The smaller the gear to be checked the smaller is the angle of setting required for the sine-bar. No master forms or base circle discs are required. By the use of two indicators and a reversible indicator finger, both sides of a gear tooth may be checked without dismounting, reversing the gear or changing the arrangement. The machine will take gears up to 12in. diameter by 12in. in length.

The subject of the final illustration, Fig. 9, is a spiral lead checking machine. This machine checks the spiral lead in preference to the spiral angle. The lead is constant whether measured at the root diameter, pitch diameter, or near the outside diameter, but the angle of the spiral changes in relation to the diameter where the angle is being checked. The machine also incorporates the sine-bar principle. After placing the gear to be checked between centres or on a stub arbor (either method may be used), the sine-bar is set at the proper angle to check the lead in question. Setting is accurately determined by two measuring buttons, and may be either side of the centre line, depending on whether the lead is left or right hand. The sine-bar carriage and indicator are moved parallel to the axis of the gear by a hand wheel. A clevis straddling the sine-bar causes the upper carriage to move at right angles to the sine-bar carriage, whilst two lapped blocks on the upper carriage cause the work-holding spindle to revolve. In this way the longitudinal movement of the indicator is synchronised with the rotation of the gear being checked, and the variation in proper lead is clearly indicated. These four machines are demonstrated at the Exhibition, producing, finishing, lapping and checking automobile gears.

There are a number of other exhibits on the stand, all of American design and construction, and we hope to refer to them in a later issue.



FIGS. 7, 8 AND 9—MICHIGAN GEAR FINISHING, GEAR LAPPING AND SPIRAL LEAD CHECKING MACHINES—MARBAIX

GEORGE SWIFT AND SONS, LTD.

Lathes and radial drilling machines are exhibited by George Swift and Sons, Ltd., of Halifax, and we have chosen for illustration in Fig. 10 an 8½in. example of the former. This tool, as will be observed from the illustration, and as will be revealed by a visit to the stand, is very neatly and sturdily designed. It is built with the intention that it shall be used with tungsten-carbide tools, and has been given a wide range of speeds and feeds. The headstock is of the all-geared type, and provides twelve spindle speeds from 27 to 1000 r.p.m., or from 13·5 to 500 r.p.m. These speeds are obtained by the use of sliding nickel chrome gears mounted on six-splined shafts running in ball bearings. The spindle itself is a 0·50 carbon steel forging mounted in preloaded Timken roller bearings. A motor situated behind the lathe drives the main gear-box through a multiple Texrope. It is arranged upon a slide so that adjustment of the Texrope tension may easily be effected. The connection between the Texrope pulley and the gear-box is made by a clutch and brake mechanism. A lever on the front of the headstock operates the reversing motion for cutting right or left-hand threads, or for sliding or surfacing in either direction.

If reference is made to the engraving there will be seen projecting from the left-hand side of the apron a single lever. This one lever controls the sliding, surfacing, and screw-cutting motions, and

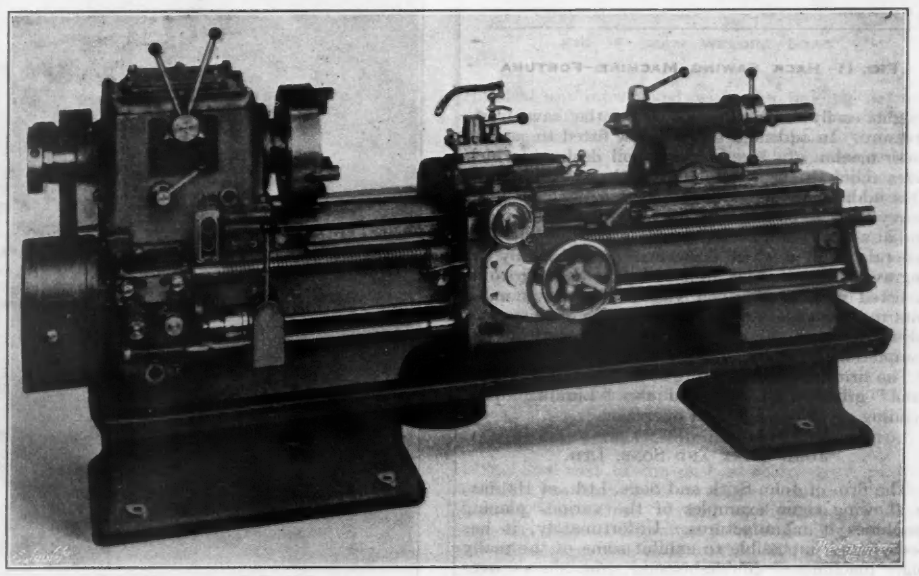


FIG. 10—8½-INCH GENERAL PURPOSE LATHE—SWIFT

also operates the worm box. Moved upwards and towards the bed it engages the surfacing motion; moved upwards and away from the bed the sliding motion, and by slipping it down into the lower slot the screw-cutting motion is engaged. The range of feeds and threads is obtained from a gear-box beneath the headstock. Nine feeds from 12 to 450 cuts per inch, and 56 Whitworth and 8 metric threads are provided for. The range of threads is obtainable by the use of change wheels. It is interesting to observe that the accuracy of the lead screw is guaranteed to be within 0·002in. in any 6in., or 0·005in. in 6ft. For the protection of the feed mechanism there is a safety clutch placed on the feed shaft in the feed box between the box and the apron.

The lathe has a bed length of 8ft., and will admit between centres work 4ft. long. It will swing over the covered ways of the bed work up to 15in. in diameter.

Another interesting lathe to be seen on this stand has a centre height of 12½in. and a bed 12ft. 4in. long capable of admitting between centres work 6ft. 6in. long. In design it is very similar to the lathe just described, but is capable of a greater number of speeds and feeds. The spindle speeds range from 8 to 800 r.p.m. in 27 steps, and 45 feeds from 8¼ to 475 cuts per inch are available. The lathe will cut 45 Whitworth and 25 metric threads.

THE NEW FORTUNA MACHINE COMPANY, LTD.

The little hack sawing machine illustrated in Fig. 11 is exhibited by the New Fortuna Machine Company, Ltd., of Bristol. It is made in several sizes, either for belt or individual motor drive and to take blades from 9in. to 18in. long. Recent improvements have included the provision of an "unbreakable" steel bow for the saw frame and a sliding

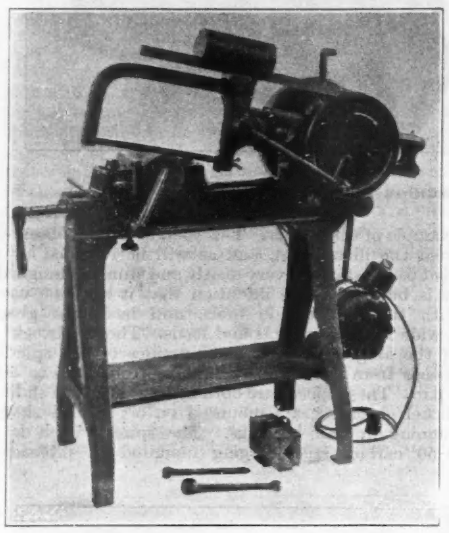


FIG. 11—HACK SAWING MACHINE—FORTUNA

weight easily adjustable to vary the saw blade pressure. In addition, there is now fitted to each of these machines a lever-adjusted oil dashpot, which gives relief to the saw blade on the return stroke. This addition will, no doubt, enable light tubes or heavy stock to be cut without changing the saw blade and at a faster rate than formerly. The machine, the general design of which is so clearly indicated by the engraving that there is no need further to refer to it, is fitted with a universal vice which allows mitre cuts to be made if desired. The stroke of the saw is adjustable, and the machine stops automatically on completion of the cut.

The firm is also exhibiting several types of "Fortuna" grinding spindles and also "Limitax" pipe bending machines for hand operation.

JOHN STIRK AND SONS, LTD.

The firm of John Stirk and Sons, Ltd., of Halifax, is showing some examples of the various planing machines it manufactures. Unfortunately, it has been found impossible to exhibit some of the really big machines — double-housing machines over 12ft. 6in. wide are made, and single-column machines with as much as 10ft. 6in. reach. Two of the planers actually exhibited are illustrated in Figs. 12 and 13. The first is a 50in. by 50in. by 120in., open-side "Hiloplane," which is in operation cutting at over 300ft. per minute with a quick return, and the other an "Ingoplow," specially designed for machining hard ingots and similar work. It is shown in operation taking a very heavy cut at a moderate speed. The illustration indicates well its massive proportions necessary to stand up to this class of work.

It is not necessary to refer at any great length to those features of these machines, which can be observed by examining the illustrations. The construction of both machines is very similar. The beds are of the continuous-plate type, with flat sliding ways on which runs a double-plate-box table. The cross slide has top and back arches to give rigidity. The Stirk patent split-field system is utilised to drive the machines. In this system, which we have described before, a motor generator set is driven from either A.C. or D.C. mains, and generates variable voltage D.C. current. The field windings of the generator are divided into two sections which oppose each other, with the result that the polarity may be altered by using the one or the other of the windings. In a similar manner the field windings of the motor driving the table are divided into two sections, but in this case one section

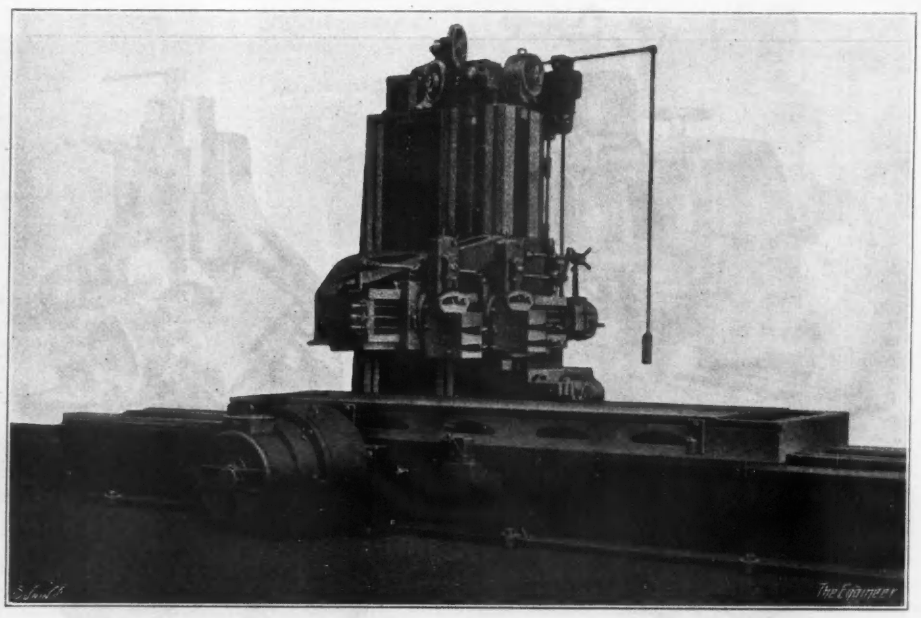


FIG. 12—OPENSIDE "HILOPLANE"—STIRK

is permanently excited. The second section is excited during the cutting stroke only, and thus a relatively slow working stroke and a fast return stroke are obtained. A range of cutting speeds is obtainable by varying the generator voltage. For this purpose two shunt regulators are provided controlling the cutting and return speeds respectively and independently. Reversals are made without shock owing to the effect of a special cushioning device which adjusts itself automatically according to the conditions of speed, length of stroke, and load. Automatic

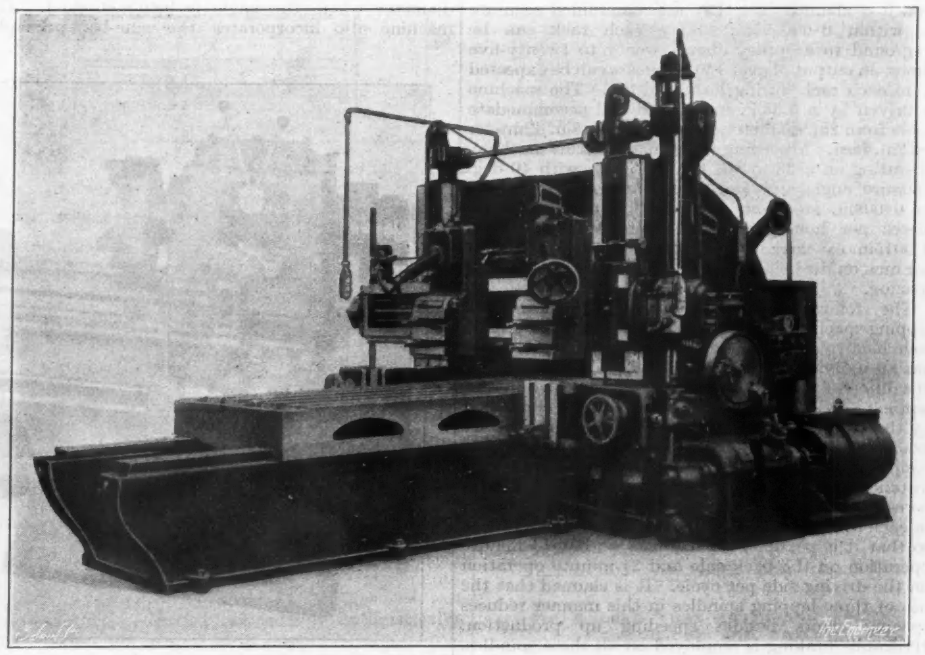


FIG. 13—HEAVY "INGOPLOW" PLANER—STIRK

control of the length of stroke is obtained by the use of light dogs, which set in operation the master switch actuating the two contactors that alter the excitation of the field windings of the generator and motor. The feed is obtained by means of a quick-acting device employing a single turn and half-turn motor, an arrangement which we described fully on a previous occasion. The feeds are readily changed or reversed, and the cross slide heads may be fed in the same direction or made to converge or diverge at will. The main control of the machines is concentrated in the balanced swivelling pendants by the use of which the table may be started, stopped, or inched, the heads power-traversed, and the cross slide elevated or lowered.

THE CARBORUNDUM COMPANY, LTD.

We have on several occasions mentioned the difficulty we experience in finding much of interest to write about the products of certain firms. Products such as cutting tools, oils, special alloys, &c., are very interesting to observe on the stand, and discussion upon them for particular applications can be absorbing. But these articles are intended to give a general survey and cannot enter into special detail. The Carborundum Company, Ltd., of Trafford Park, Manchester, is a maker of a large variety of grinding wheels and abrasives, and in the past it has exhibited examples on its stand. It has been considered, however, that this method of display insufficiently linked the grinding wheel with its real purpose, and on this occasion, with the object of demonstrating practically the quality of the products, the firm is exhibiting ten units covering the chief classes of grinding machines. Each unit is self-contained and designed to display to the best advantage the particular qualities of the wheel concerned. Interesting work examples are also to be seen, and there is an exhibit of the raw materials from which wheels and abrasive products are made. A film is shown at intervals illustrating the manufacture of the crude materials and of the finished product.

PITTLER WERKZEUGMASCHINENFABRIK A.G.

A group of Pittler turret lathes manufactured by the Pittler Werkzeugmaschinenfabrik A.G., of Leipzig-Wahren, is exhibited by Dowding and Doll, Ltd. These

machines have been designed for the production of complicated components requiring a high degree of accuracy. A leading feature is the Pittler turret, which carries twelve to sixteen tools and revolves around a horizontal axis. In the various indexing positions the upper central tool hole is aligned with the main spindle of the machine. Fig. 14 shows the new R.D. II 47 lathe with a standard spindle speed of 990 r.p.m., which may be increased to 1250 r.p.m. A high-speed model has a spindle speed of 3000 r.p.m. and can also be supplied. The model we illustrate has a spindle bore of 47 mm., with a capacity for bar

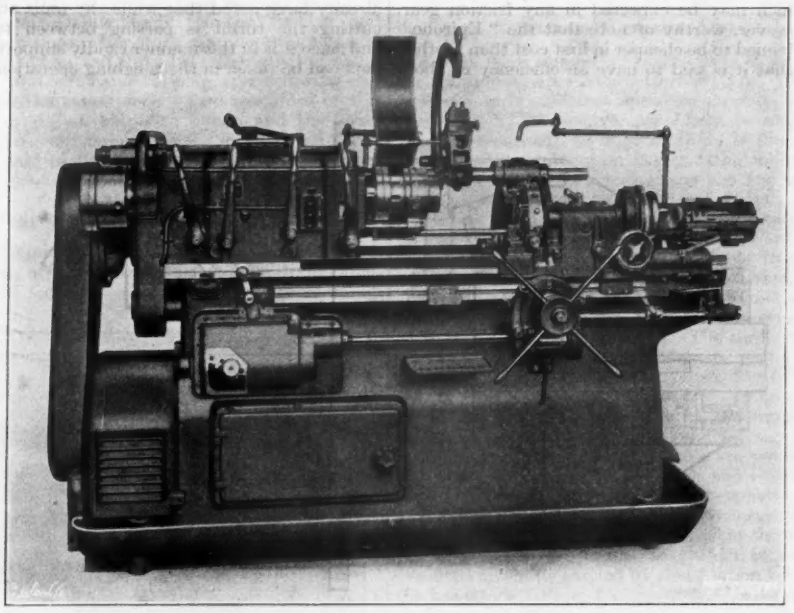


FIG. 14—TURRET LATHE—PITTLER

work up to 45 mm. For chuck work the lathe is designed to deal with diameters up to 220 mm. The drive is taken to the main spindle by vee belts from the motor, which is housed within the lathe base. The driving pulley runs at a constant speed in either direction, and reversal is effected by a clutch built into the headstock. By reason of the high belt speed there is ample power, it is claimed, for the range of diameters already referred to. All the principal shafts, including the driving shaft and the fast-running intermediate shafts, run in either ball or roller bearings. Several other types of Pittler lathes

FIG. 15—FORCED AIR CIRCULATION TEMPERING FURNACES—WILD-BARFIELD

are shown, which, together with standard tools, enable a wide range of varied work to be economically dealt with.

WILD-BARFIELD ELECTRIC FURNACES, LTD.

Among the electric furnaces shown in operation by Wild-Barfield Electric Furnaces, Ltd., of Elecfurn Works, North-road, Holloway, N.7, is a patented "heavy" hairpin-box-type furnace for the heat treatment of ferrous and non-ferrous materials. It has an exceptionally robust heating element which can easily be replaced even when the furnace is hot, thus saving time and avoiding interruption of production. Forced air circulation furnaces with charge progress recorders are shown, and furnaces of this kind for large-scale production, and for tool-room work, are to be seen in operation. They are suitable for all low-temperature treatments involving close temperature control. The patented charge progress recorder serves the dual purpose of controlling and recording the furnace temperature, and of showing when the charge has reached the desired temperature. Two Wild-Barfield forced air circulation tempering furnaces similar to those to be seen in operation on the stand are shown in Fig. 15.

Among other exhibits in operation is an automatic hardening furnace for hardening carbon, carburised and low alloy tools and components, both the vertical and horizontal types of these furnaces being represented.

High-temperature furnaces for high-speed steel treatment to be seen on the stand are designed for general high-temperature work, and are provided with automatic compensation for the change in the resistance with age of the recrystallised carborundum elements. Other exhibits consist of muffles of many types, a Vickers hardness-testing machine, hardening shop materials, quenching oils, and photographs of large heat-treating and melting equipments.

VARLEY PUMPS AND ENGINEERING, LTD.

On the occasions of previous Exhibitions we have described the small pumps made by Varley Pumps and Engineering, Ltd., of North Acton, London. It will be remembered that these pumps do not operate on the "gear" principle, but that the moving part is given a "paracyclic" motion. The body of the pump encloses a displacer carried on two symmetrically placed cranks of suitable throw. The crank shafts are driven through gears from a common driving spindle carried in a gear cover. Leakage is prevented by a packing gland and a bearing of suitable length takes the belt pulley load. A special variety of this device is exhibited acting as a "Suds" pump. It is so arranged that it may be demonstrated under working conditions. For instance, the self-priming characteristic is shown by the operation of a control cock on the suction line. A by-pass valve arranged in the end cover allows the discharge to be shut off with a minimum load on the pump, and produces a smooth steady flow when the discharge cock is open. The makers state that they have found an increasing tendency in large works to supply a group of machines with coolant from a single pump. For this purpose the general service "Varley" pumps are suitable, and a large range of capacities is manufactured.

SOAG MACHINE TOOLS, LTD.

Among the range of automatic spot and seam-welding machines which are manufactured by the Soag Company, of Düsseldorf, and built under licence in Great Britain by Soag Machine Tools, Ltd., of London, there is the high-speed spot and seam resistance welder shown in Fig. 16. It is representative of a series of machines which have been specially developed for high-production outputs of drums, tanks, motor car wings, and steel furniture parts. The machine illustrated has a maximum transformer rating of 150 kVA, and is built for circumferential welding. With this machine a large longitudinal seam of 16 gauge material can be welded at speeds up to 10ft. per min. As our engraving shows all the working parts are enclosed within the casing, but the switches and controlling motor are neatly grouped at the right-hand side of the machine. The motor is of the flanged pattern, and, working through a worm and clutches, it furnishes the rotary motion for the electrodes and the pressure required. The

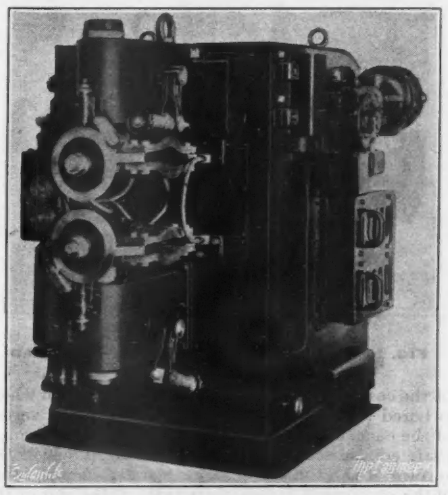


FIG. 16—SEAM WELDER—SOAG

clutches are interlocked with the welding current controls, and either electric or pneumatic interlocking and control can be utilised. The primary switch is of the contactor type, operated by push-button or foot pedal, and by means of two plug switches the welding current can be regulated on fifteen or twenty-five steps. The speed of the electrodes may be varied in gradual steps in a 4 : 1 ratio. Most of the Soag welders shown on the stand are designed for easy conversion from spot to seam welding, or *vice versâ*, and some of the machines are built for stitch welding up to 200 spots per minute, and also mesh welding, for which an adjustable cam switch with variable speed and length of weld is employed. The machines we have referred to include a range of six with maximum transformer ratings from 25 up to 150 kVA.

DELLREAD GEARS (HOLDINGS) COMPANY, LTD.

The fact that in the past so many gears of the friction type have been developed, some to fail in practice, and others to find applications, usually, however, only in a limited field, demonstrates that the advantages are considerable if the mechanical difficulty of construction can be overcome. One of the main problems facing designers of this class of gear is that of avoiding undue slip, which, besides causing inefficient operation, also is productive of wear. In the attempt to reduce slip the pressures between the working surfaces are increased until a point is reached where, indeed, the slip is small, but in which local distortion of the surfaces has led to a short working life and frequent overheating. It is claimed for the design of the gear illustrated, and known as the "Epirolic" friction reduction gear, that means of overcoming these disadvantages have been discovered. The device is made by Dellread Gears (Holdings) Company, Ltd., of 2, St. Anns-lane, Great Peter-street, London.

As will be seen from the line engraving, Fig. 19, an epicyclic arrangement has been adopted, so that

the driving and driven shafts are in line. The driving shaft is carried in ball bearings, one of which, for a reason to be explained later, is slidably mounted in the outer casing. It carries at its end the sun wheel of which the working surface is the frustrum of a 20deg. cone. The outer part of the compound driven shaft is carried by two ball bearings slidably mounted in the casing, and carries at its inner end a spider

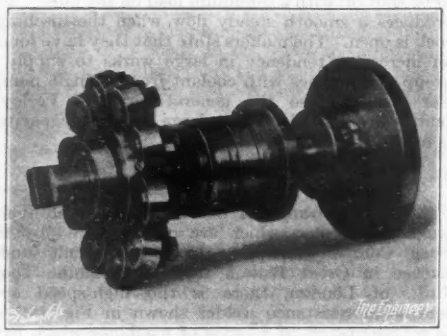


FIG. 17—PART ASSEMBLY OF "EPIROLIC" GEAR—DELLREAD

disc. A number of tapered rollers are mounted on ball bearings on pins fixed by nuts and spring washers in slots distributed evenly around the periphery of the disc. Between the slots of the disc the metal is cut away in order to allow a certain degree of freedom for each roller to take up its position and equalise the pressure with which the rollers bear against the working faces. Encircling the rollers and forming part

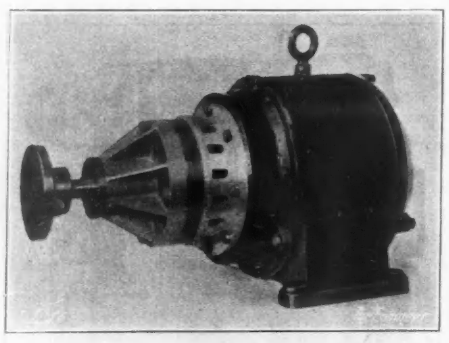


FIG. 18—GEAR FITTED TO MOTOR—DELLREAD

of the casing there is a ring, the inner surface of which is bored taper to an angle of 35·2 deg. The vertex of the cone, of which the surface of this ring forms a part, coincides with that of the cone of which the surface of the sun wheel forms a part. A projection of the compound driven shaft rides in the end of the driving shaft in a double-purpose—thrust and journal—ball bearing. Upon consideration it will be observed that when the shafts are assembled together and the rollers are tightened down upon the surface of the sun wheel, the whole becomes a unit of which no part can have a separate movement. It is, therefore, a simple matter not only to adjust for the correct running pressure between the rollers and the outer ring, but also to take up wear. At each end of the casing the driving and driven shafts respectively are encircled by adjusting nuts screwed into the ends of the casing and bearing against the outer races of the ball bearings. Lock nuts hold the adjusting nuts in place. By means of these adjusting nuts the axial position of the two shafts in the casing may be delicately adjusted, for the ball bearings carrying the shafts bear up against shoulders upon them. The two parts of the driven shaft are connected by ball bearings running in tapered slots, after the fashion of a free-wheel. At starting they jam the two parts of the shaft together and also force the rollers on the spider against the ring, thus providing for the heavy starting torque.

We need hardly repeat all the advantages that are claimed for this gear, since many of them are those which may be expected in any friction gear. It is, however, worthy of note that the "Epirolic" gear is claimed to be cheaper in first cost than toothed gears; that it is said to have an efficiency of about 98 per cent., and that it is very compact for the power transmitted. It should also be said that the use of ball bearings is not a necessity, and for low-speed heavy duty ordinary bearings of other types can be used. By placing several units of the type described "in series," a change-speed gear-box can be formed in a manner similar to that in which any multi-speed epicyclic box is constructed.

Some parts of a gear are shown in Fig. 17, and another engraving, Fig. 18, shows a gear attached to the end of an electric motor shaft.

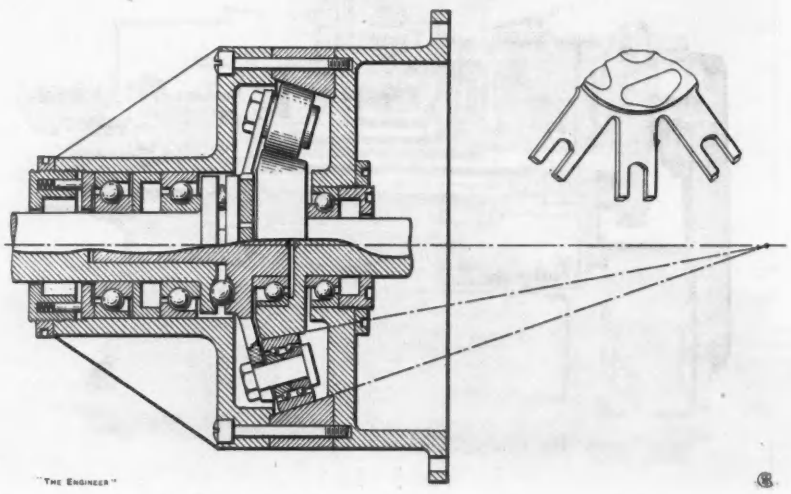


FIG. 19—SECTION THROUGH "EPIROLIC" GEAR—DELLREAD

BUTTERWORTH AND CO.

Three automatics which have never been exhibited before are to be seen on the stand taken by Butterworth and Co., of Rochdale. A chucking machine is illustrated in Fig. 20. One of its most noticeable features is the overhead slide supported upon the headstock. When desired, this slide can be rapidly moved out of position by releasing two cramps and turning the star wheel to be seen in the engraving. Heavy or bulky parts can then be mounted in the chuck. Before cutting is begun the slide should be returned to the forward position so that the turret face brackets shall be supported. The headstock is adjustable along the bed to suit varying lengths of work, the adjustment being effected by a rack and pinion. It is rigidly clamped down when it has been moved to the desired position. The main spindle is a carbon steel forging, and it is mounted in Timken roller bearings. Speeds obtainable range from 13 to 256 r.p.m., divided into nineteen groups of three, or fifty-seven speeds in all. By the use of additional change gears other speeds are obtainable. In each group of speeds any one of the three can be automatically selected to operate in conjunction with the particular cutting tools being employed.

The turret, as will be observed from the engraving, has four faces. It is mounted on a cone seating and carried by a slide with wide bearing surfaces. It is automatically clamped down after indexing. Those wise in the knowledge of automatics will already have noted that while the tools are actually cutting the turret is passing between two slides, and since it is in this manner rigidly supported, heavy cuts can be taken in the roughing operations without fear of overstepping the mark. Thus the finishing cuts can be very light and, consequently, the finishing tools will maintain size for a longer period. The two cross slides are independently mounted and have 10in. of longitudinal adjustment. They are controlled independently of the turret. The range of feeds available—from 0·005in. to 0·118in. per revolution—is split up into groups of five, which overlap one another so that it is possible to select a group which suits the work in hand. Automatic changes of feed are obtained by inserting hardened pegs in the cam drum at suitable positions. The machine illustrated has a swing over the bed of 26in. and over the cross slide of 16½in.

The subject of the second illustration, Fig. 21, is an all-geared head automatic screw machine for bar work. With a small number of change gears seventy-eight forward and seventy-eight reverse speeds are obtainable, ranging from 43 to 1280 r.p.m. on the machine illustrated. The speeds are divided into three groups, suitable for mild steel and brass, mild steel, and alloy steels. In the first group the speeds are based on approximately 300ft. per minute for bar-stock ranging from ⅜in. to 1⅝in. diameter, advancing by $\frac{1}{16}$in.; in the second group on approximately 150ft. per minute, for bar-stock from ⅝in. to 1⅝in. diameter, advancing by $\frac{1}{8}$in., and in the third group on approximately 60ft. per minute, for bar-stock from ⅝in. to 1⅝in. diameter, advancing by $\frac{1}{16}$in. In the first

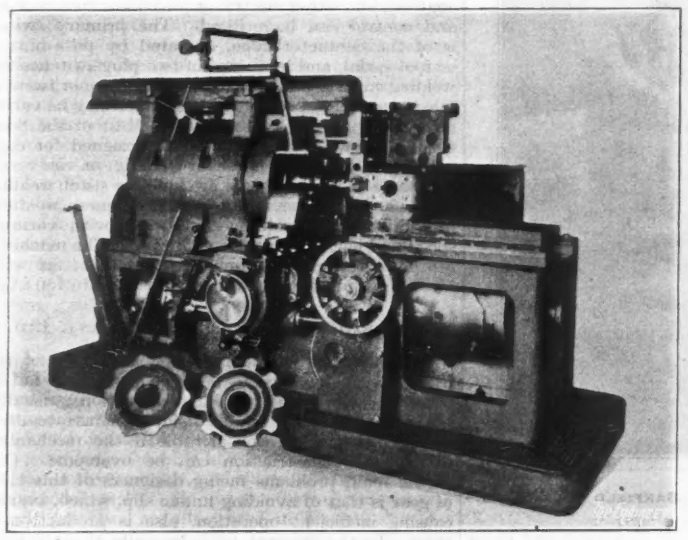


FIG. 20—CHUCKING AUTOMATIC—BUTTERWORTH

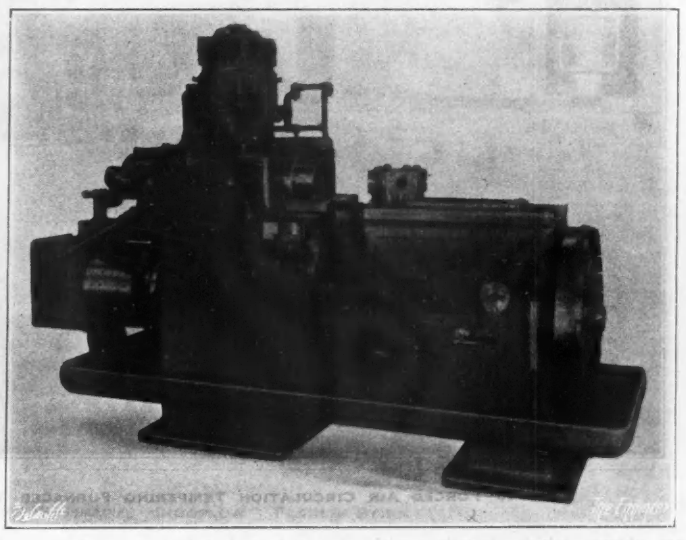


FIG. 21—SCREW AUTOMATIC—BUTTERWORTH

group, for bars from ⅛in. to 1⅝in. diameter, the cutting speed is under 300ft. per minute. There are two automatic changes of speeds and an automatic change from forward to reverse, and *vice versâ*. The time taken to effect these changes is only a fraction of a second.

The slowest feed available is 0·96in. per minute, and the fastest 18·2in. per minute, intermediate speeds being determined by the adjustment of strip cams. It is possible to employ either a very close or a very wide ratio between the turning and threading speeds. Owing to the capacity of the machine in reverse it is unnecessary for form or cut-off tools to be mounted on the rear slide inverted. Work that requires tapping can be machined without having to use left-hand cutting tools for the turning and drilling operations. Bar-stock may be automatically tapped right hand and threaded externally left hand, and right and left-hand tapping and screwing can be done on the same piece. Two machines of this type are exhibited, one with a ¾in. and the other with a 1¼in. spindle capacity. Special attention has been paid in the design to the requirements of tungsten carbide and other alloy cutting tools.

Robert Berninghaus and Sohn.

Two machines shown on the stand of Soag Machine Tools, Ltd., of 7, Juxton-street, Lambeth, London, S.E.11, call for brief mention. They are built by

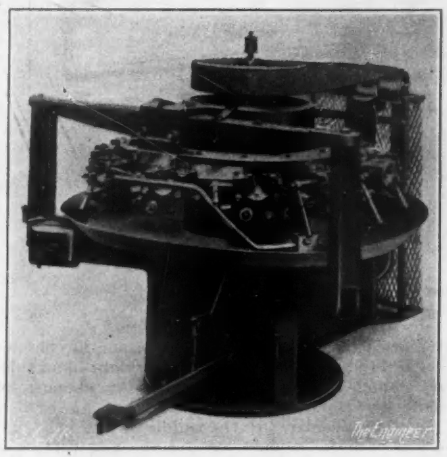


Fig. 22—Rotary Multi-Spindle Drill—Berninghaus

Robert Berninghaus and Sohn, of Velbert, Rhineland, and are illustrated in Figs. 22 and 23. Fig. 22 shows a rotating multi-spindle high-speed drilling machine, which is the smallest of a series of three machines equipped with eight, twelve, and sixteen spindles respectively. It has been designed for the mass production of small parts, such as wing nuts, Stauffer lubricators, lock and key components, chain pins, and small parts used in motor car and cycle manufacture. Special features include arrangements for the continuous sharpening of the drills and the prevention

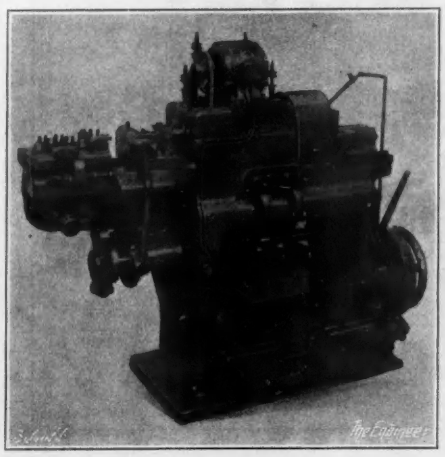


Fig. 23—Automatic Machine—Berninghaus

of their breakage. The work clamps are self-closing, and are automatically withdrawn before and after the drilling operation. In addition to drilling, the machine is designed to perform simultaneously either filing, slotting, or tapping operations. The machine is built under patents and on the eight-spindle machine we illustrate outputs up to sixty-six pieces per minute can be obtained.

The other machine—see Fig. 23—is an automatic universal forming machine. It produces from reeled wire or drawn bar stock, either round or square or soft or hard, small parts such as special bolts, pins, bushes, &c., in quantities up to ninety pieces per minute. The actual machining operations which can be performed are eight in number, but the machine will carry out such work as straightening, cutting off, turning, shaping, drilling, and countersinking, also knurling, taper turning, and polishing. The stock is fed from a reel and is straightened by a rotary device during the feeding operation which can be controlled by micrometer screws. The stock is fed to the turning tools through collets. The particular machine we illustrate, type DM1, has been designed to utilise round stock up to $^{9}/_{32}$in. diameter, but other machines in the same series will deal with stock up to $^{35}/_{64}$in. diameter. The two machines we have described should be inspected in order to appreciate fully the ingenious mechanisms employed.

Alfred Herbert, Ltd.

A very large number of machines is to be seen on the stands taken by Alfred Herbert, Ltd. We have, however, only sufficient space to mention a few of these which, we believe, are likely to attract the greater attention. In Fig. 25 there is illustrated a new No. 12 combination turret lathe intended for heavy work. It has a swing over the bed covers of 23½in. and over the cross slide of 15½in., and the maximum distance from the flange of the spindle to a face of the turret is 75in. Sixteen forward spindle speeds and eight reverse are available from 15 to 598 r.p.m. and 15 to 474 r.p.m. respectively. The chasing saddle is provided with sixteen rates of feed from 6·2 to 241 cuts per inch and transverse feeds from 10·4 to 408 cuts per inch. The turret slide has the same number and range of feeds as the chasing saddle. The machine is driven by a 25 H.P. motor running at 1430 r.p.m. The motor is mounted behind the headstock and drives it through texropes. We need hardly refer to every detail of the design. Attention may be directed, however, to a few points which will indicate the care with which the machine has been designed and constructed. The spindle is bored with a 6½in. diameter hole and runs in large roller and double purpose ball bearings. Nickel-chrome steel gears, of which the teeth are ground to form, are mounted on shafts carried by anti-friction bearings in the headstock. From the top of the headstock there projects a stout support bar for turret tools. It is supported along the full length of the head and its projection can be adjusted by the use of a pilot wheel pinion and rack. The lathe can be started or stopped from either the headstock, the saddle, or the turret slide. The mechanism for the automatic longitudinal and transverse feeds of the saddle and for chasing is enclosed within the apron, which acts as an oil tank, Feed change levers are conveniently arranged on the front of the apron. The leader shaft is driven by an enclosed train of gears connecting the spindle with the chasing gear-box which is bolted to the bed below the headstock. The box contains gearing by which three pitches of right or left-hand thread can be cut with each leader. The same train of gears also drives the feed shaft.

Like that of the saddle, the turret apron contains the mechanism for automatic longitudinal feed. The turret itself is hexagonal and is arranged in a frictionless mounting which enables it to be easily rotated by hand in either direction, even if it carries heavy unbalanced tools. There is no power rotation and its absence removes all possibility of danger to the operator. Quick-power traverse along the bed is provided for the saddle and turret slides. It is driven from the constant-speed shaft of the headstock and engaged by levers on the saddle and turret slides.

The No. 3A auto-lathe, illustrated in Fig. 26, is designed for machining parts of medium size that lie between the small work suitable for the "Auto Junior" and the heavier parts that require the use of the "No. 4 Auto" lathe. As a general guide to the type of work handled it may be said that for work of disc form not exceeding 2in. in thickness diameters up to 9in. may be machined. For work approximately the maximum length, which is 6in., diameters up to 5in. can be dealt with. Its speed range makes it suitable for work made from non-ferrous materials as well as from cast iron or steel.

The headstock is arranged for driving either by individual motor or from a line shaft. When driven by individual motor the latter is mounted on a hinged base carried by a bracket on the headstock. Texropes connect the motor to the pulley on the head, and an adjusting screw in the motor bracket enables the tension of the ropes to be maintained. For controlling the motor a hand-operated starter is carried on the motor bracket. The headstock is adjustable along the bed. It is moved by a screw at the left-hand end and clamped by bolts to the flanges at the front and back of the bed. The pick-off gears are housed in a casing at the front end of the headstock and there is a gear change operated by a hand crank on the front side of the head. The automatic speed change is obtained through a double multiple disc friction clutch in the headstock. The latter is operated by dogs on the speed change disc through levers and a connecting-rod. The speed change disc is mounted on the cam shaft below the headstock and is arranged to slide with the headstock when the latter is adjusted on the bed. A lever on the top of the headstock enables the double clutch to be operated by hand. In the neutral position a powerful brake is applied automatically to the spindle. Another lever on the headstock, longer than that just mentioned and raised above it, operates a starting clutch on the driving pulley shaft. When moved as far as it will go to the left, this lever, besides disengaging the starting clutch, withdraws the driving gear on the pulley shaft sideways clear of the driven gear on the next shaft. This action makes the mechanism in the headstock "dead" and enables the pick-off gears to be changed with complete safety to the operator. An interlock prevents the cover of the pick-off gear casing from being taken off till the starting lever has been moved to the left. The main spindle is mounted on large parallel roller bearings and has two opposed double purpose ball bearings for taking the thrust in both directions and also part of the journal load. An overhead support bar for turret tools is carried by a strong bracket bolted to the front end of the headstock.

The turret slide is actuated by the cams on the drum through a roller carried on an extension cast solid with the slide. A thrust plate takes the side thrust of the cams and relieves the ways of the bed from torsional stress due to this cause. The turret has four faces and the tool holes are relieved for rather more than half their circumference, to enable tools to be inserted and removed easily and to prevent wear of the holes.

The cross slides are independent, which enables them to operate either simultaneously or at different points of the cycle. They are actuated by forward and return cams on two adjacent cam discs which are adjustable around the cam shaft and can be locked to it positively. The discs can be reached by opening

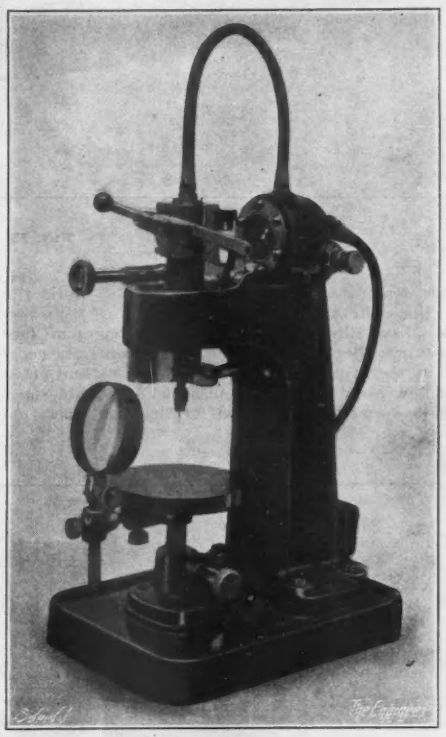


Fig. 24—"Aerospeed" Drilling Machine—Herbert

a door at the front of the lathe without removing any cover. The cams move the slides through double-ended levers, the upper ends of which are attached to the slides by connecting-rods which have a fine adjustment for varying the length of stroke.

From a pulley on the rear of the main spindle, which is connected to a pulley on the hollow feed shaft at the back of the bed, a belt drives the feed motion. There are two ranges of feeds, fine and coarse, and the change from one to the other is made by a hand lever at the back of the feed box. Each range consists of five feeds, and the changes are obtained automatically through a sliding shaft with a rising and falling key, which can engage any of the five gears loose on the shaft.

The little tool illustrated in Fig. 24 is termed the "Aerospeed" drilling machine, a title not inappropriate to the spindle speed of 60,000 to 80,000 r.p.m. which is attainable. The largest diameter of drill that it will take is $^{1}/_{16}$in., and the smallest 0·010in. Its stroke is 1⅜in. The machine has been developed as the result of a good deal of experimental work. It has been found that owing to the exceeding fineness of the drills used, ordinary hand-feed methods are unsuitable. Special arrangements are therefore made for controlling the feed. By depressing the hand lever the end of a second lever at the side of the machine is brought into contact with a stop so set that the drill point is just above the work. While pressure is still maintained on the hand lever, the stop is withdrawn by means of a fine thread screw with a knurled head. It is stated that the operator is able to determine the correct feed by listening to the high-pitched note of the drill as it penetrates the metal. A fall in the tone, for instance, indicates too coarse a feed. On release of the pressure upon the

control lever the drill spindle returns to its normal position under the influence of a spring-loaded lever operating upon a flange on the spindle. The spindle is driven by an air motor, the maximum air pressure required being 80 lb. per square inch. A throttle device allows the speed to be adjusted and a dial at the top of the column indicates the speed in use. The inclusion of a magnifying glass in the equipment demonstrates the fineness of the work the machine is intended to carry out.

We have already described in the pages of THE ENGINEER the "Pre-optive" head recently brought out by the firm. It is to be seen on the stand fitted to a new No. 4 senior capstan lathe, and enables any spindle speed to be selected for the next operation while the previous operation is in progress. The new speed is obtained, when required, by pulling a single lever. The same tool can be fitted with a "wide range" head, of which the capabilities are fully implied by its title; or a geared electric head. In the latter type the head forms a housing for the stator of an alternating-current motor, the rotor of which is mounted on the main spindle on ball bearings. By the movement of a hand lever the clutch engages the rotor to the spindle, giving, through a special patented pole-changing switch, four fast spindle speeds. Alternatively, by the motion of the hand lever in the opposite direction, the rotor is made to drive the spindle through reduction gearing, and four slow spindle speeds are thus obtained. An independent switch controls stopping, starting, and reversing.

The No. 35 universal milling machine illustrated in Fig. 27 is a self-contained unit driven by its own motors, and has an unusually wide range of spindle speeds and feeds, with quick power traverse to the three motions of the table. Complete control is provided from the back as well as from the front of the knee. The column is widened near the base to form a housing for the main motor, which is mounted on a hinged base and drives the pulley on the machine by texropes. The ropes are completely guarded, and an adjusting screw enables the tension of the ropes to be maintained. The motor housing is ventilated by screened openings on both sides. A starting lever on the left-hand side of the column controls the machine. By the movement of this lever, a brake is first released and then a switch operates to start the motor. The reverse movement of the lever first opens the switch and then applies the brake. In addition to stopping the spindle quickly, the brake holds it while the draw bolt or arbor nut is being tightened. The overhanging arm is moved by pinion, rack, and pilot wheel, and can be very firmly clamped by a lever operating a taper gib. Twenty-four spindle speeds are provided by the driving box, which is built as a separate unit, and is housed inside the column. The feed box provides twenty-four rates of automatic feed. It is housed partly inside the column, being firmly bolted to a facing on the right-hand side. Feed changes are independent of the changes of spindle speed.

For the movements of the saddle on the knee and the knee on the column, one of the faster feeds is used as a quick traverse, as the total amount of movement in these two directions is comparatively short.

There are many more machines on the Alfred Herbert stands than those we have described, and we have not mentioned any productions of those firms, both foreign and British, for which Alfred Herbert, Ltd., is the agent. At a later date, when we have had a further opportunity to examine the machines on these stands for ourselves, we hope to continue this description.

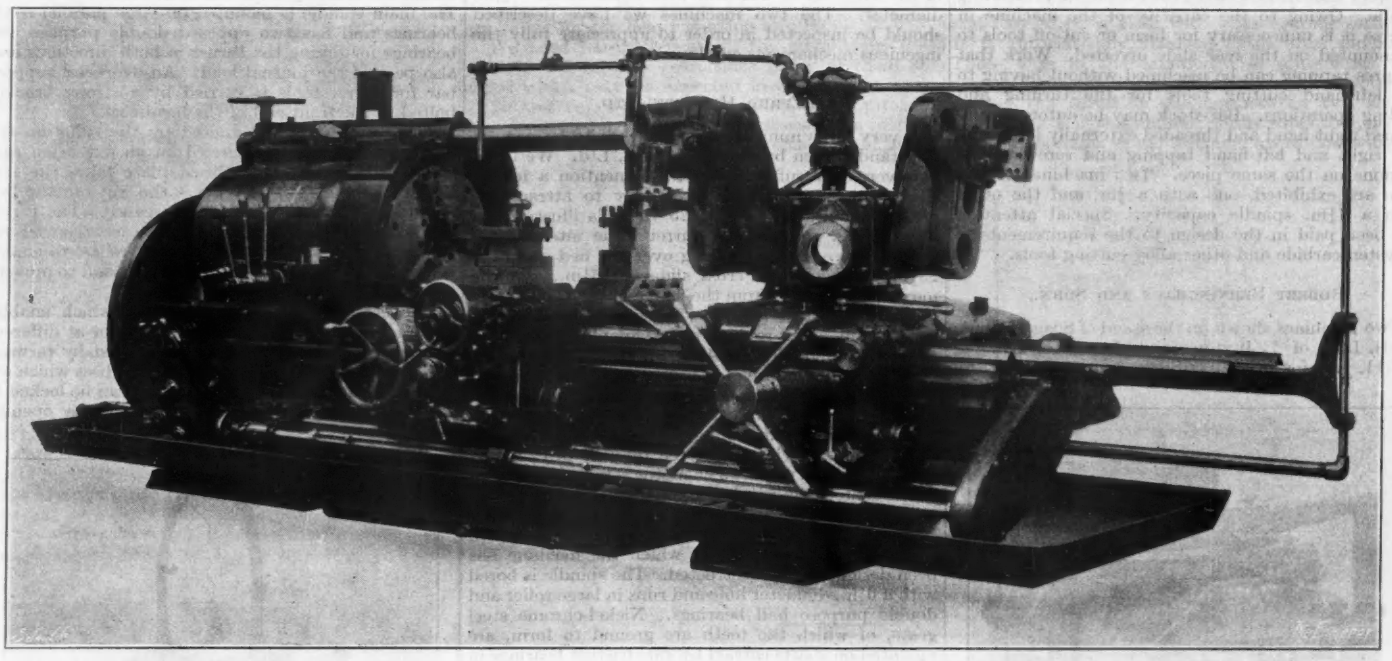


FIG. 25—COMBINATION TURRET LATHE FOR HEAVY WORK—HERBERT

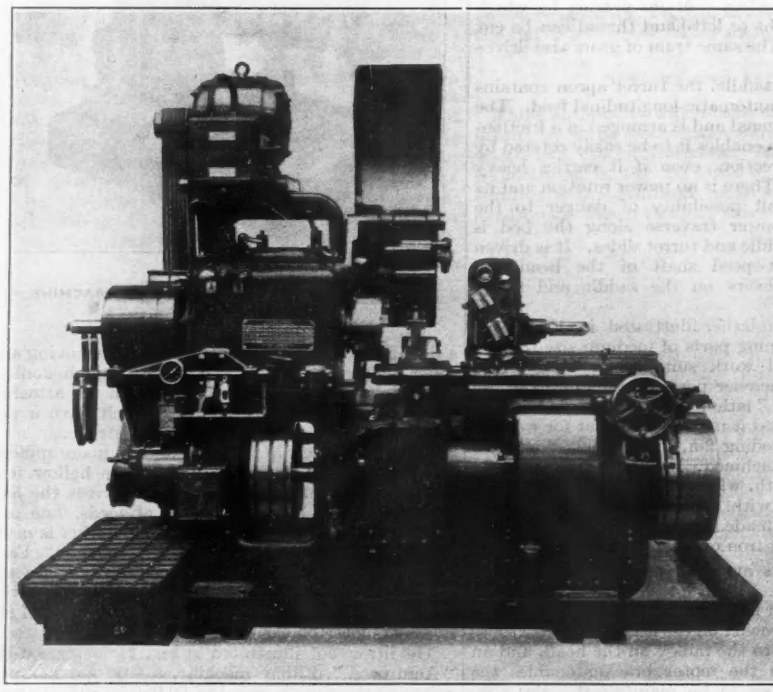


FIG. 26—AUTO-LATHE—HERBERT

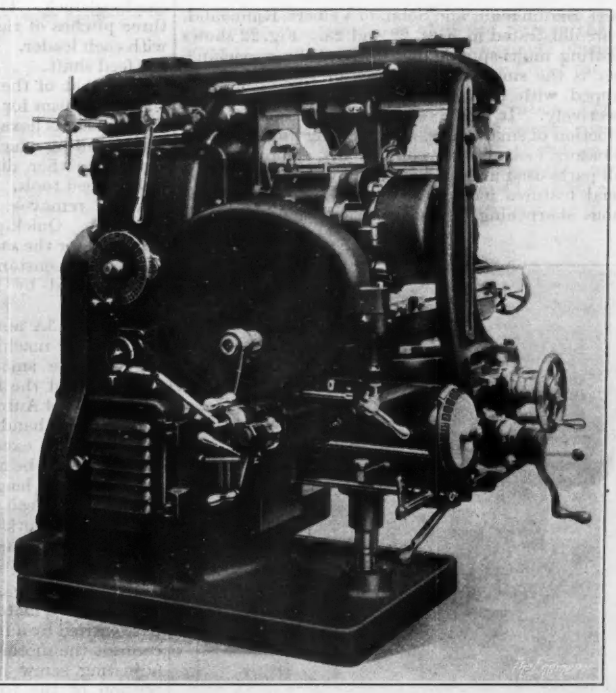


FIG. 27—UNIVERSAL MILLING MACHINE—HERBERT

A Seven-Day Journal

The Liberation of the Electron.

A LECTURE, entitled "The Liberation of the Electron and its Industrial Consequences," arranged by the Royal Institution and the British Science Guild, was delivered by Mr. Clifford C. Paterson, director of the G.E.C. research laboratories, at the Royal Institution on Wednesday, November 21st. After the work of J. J. Thomson, the lecturer explained, electricity had no longer to be studied and thought of in the mass. In the same way as physiologists had learned that disease could be envisaged in terms of isolated germs and their life history, so the physicist had found that electricity could be thought of in terms of the individual electron, its habits and affinities. One of the two main reasons for the practical usefulness of electricity was its ease of control. The other was its transportability. It was in the direction of the control of electricity that the free electron had given the engineer new and extraordinary powers, and the secret of the revolution was that electricity could now be freed from conductors. A stream of free electrons in a vacuum or a gas could be manipulated with such facility that the energy could be increased or decreased at the rate of millions of times per second, or, alternatively, as slowly as desired, and no limit was set to the amount of energy which could be so controlled. The two principal electron liberator devices which the lecturer discussed were the thermionic valve and the photo-electric cell. To illustrate their potentialities he demonstrated experimentally how the mechanical movements of a needle on a gramophone record could be converted into electrical impulses, and after being impressed on the current in a luminous discharge lamp, could be changed into light pulses. The beam of light carrying exactly equivalent modifications was passed across the room and reconverted by a photo-electric cell into electrical pulses which were amplified and reconverted into sound waves by means of a loud-speaker. Finally, Mr. Paterson dealt with the use of the free electron in connection with the art of electric lighting. The many coloured luminous discharge tubes used for display purposes in the streets had, he explained, led the way to more brilliant and more efficient light sources, and some of them gave much more light for the electricity consumed than filament lamps.

The Late Mr. J. A. Brodie.

MUNICIPAL and road engineers will learn with regret of the death of Mr. John Alexander Brodie, M. Inst. C.E., who was for twenty-seven years the City Engineer of Liverpool, and a Past-President of both the Institution of Civil Engineers and the Liverpool Engineering Society. Mr. Brodie, who was seventy-six years of age, died on Friday, November 16th, at his home, Aigburth Hall, Liverpool. He was born in Forfarshire, and served his apprenticeship in the workshops of the Mersey Docks and Harbour Board. Having gained a Whitworth Scholarship, he spent three years of training at Sir Joseph Whitworth's works, and after a short time on Spanish harbour work he joined the Liverpool City Engineer's Department. He left that department in 1882 in order to set up in practice in Liverpool as a consulting engineer with Mr. J. T. Wood, with whom he designed a combined refuse destructor and steam generator. In 1898 he was appointed the City Engineer of Liverpool, and in over a quarter of a century's service he transformed the city and its methods of transport and carried through many town-planning schemes. He was the joint engineer with Sir Basil Mott for the Mersey Tunnel, and resigned his office as City Engineer shortly after accepting that responsibility. In 1912 he was lent by the Corporation to advise the Government of India on the laying out of the new capital at Delhi, and in 1931 he attended the official opening of New Delhi. Mr. Brodie was a valued member of the Advisory Committee of Engineers to the Road Board, and for many years Associate Professor of Engineering in the University of Liverpool.

Ribbon Development.

THE British Road Federation has recently handed to the Minister of Transport a memorandum containing proposals for dealing with the problem of ribbon development. In it the suggestion is made that it is of primary importance to commercial motor transport that the present system of ribbon development alongside main roads should be speedily brought to an end. The powers given to highway authorities under the Development and Road Improvement Funds Act of 1909, and the Town and Country Planning Act of 1932, are reviewed and instances are cited of the action taken by the Surrey, Essex, and Middlesex County Councils under the 1932 Act by which power has been acquired to keep main roads clear of ribbon development by the compulsory purchase of land at the sides of the roads, or the prohibition of all building operations within 200ft. of a main highway. The Federation suggests that these same powers should be extended at once by a general Act to every County Council in the country, and that each authority should be obliged strictly to enforce them. They could quite well be applied both to new and unspoilt arteries, or to existing main roads where ribbon development has started but can be stopped. Such a measure, if vigorously applied, it is suggested, should be sufficient to prevent any further extension of ribbon development, but further steps can be taken to improve the many fine arterial roads which have already been marred by ribbon building. The proportions of such roads are almost always 100ft. from fence to fence, with a 30ft. carriageway and 35ft. of grass margin, and footpaths at each side. If a new 15ft. carriageway were to be driven through each grass margin, it could accommodate all the local traffic, the standing private cars, and the tradesmen's vans. If additional bays could be provided for omnibus stops, then most of the incidental traffic would be cleared off the main highway, which would then be left clear for fast through traffic. Work on these lines has already been begun on the Kingston By-pass, and it should, it is claimed, be now extended.

A Five-Day Week Factory Scheme.

IN view of the fact that not a few engineering works are compelled to work a five-day week, owing to lack of orders, while in other special cases known to us high production is being maintained on a five-day week basis, Sir Richard Redmayne's report to Lord Trent on the five-day week plan which has now been made permanent at Boot's Nottingham factory may not be without interest to some of our readers. Sir Richard states that he finds that the working of the five-day week has proved an unqualified success, both from the business point of view and from that of the employees. He further expresses the opinion that if it be continued over the winter months, which has now been done, the results will prove equally satisfactory. The experimental period was from April 30th last till September 29th, and about 85 per cent. of the 5000 to 6000 employees were dealt with in a uniform manner by adhering, on five days of the week, to the same hours per diem as before the experiment, and discontinuing all Saturday work, making a reduction of five hours. Sir Richard finds that the effects in regard to enhancement of health and contentment, regularity of attendance at work, and diminution of absenteeism have been very marked since the introduction of the experiment. His opinion is that the experiment might be applied at many works, such as, for instance, large printing works, and certainly at works in which production and distribution are vested in the same concern, more especially where wages do not constitute a high proportion of the selling price. Each case, Sir Richard Redmayne suggests, would have to be considered on its merits.

Coal Dust Engine Research.

IN a letter to *The Times*, which was published on Saturday, November 17th, Professor W. A. Bone, of the Imperial College of Science and Technology, supports the plea advanced in Sir Harry McGowan's recent Presidential Address to the Institute of Fuel for the establishment of a Fuel Development Committee, financed by a tonnage levy, and further research into the use of powdered coal in engines of the Diesel type. In his James Watt Anniversary Lecture on "Britain's Coal Problem," delivered in Greenock on March 4th, Professor Bone suggested that if it were prosecuted with sufficient energy the problem of de-ashing coal and its use in internal combustion engines might well be solved within a decade. Since that time Professor Bone states that he has been in touch with Dipl.-Ing. Rudolph Powlikowski regarding his coal dust engine experiments, and also with a Belgian colliery organisation which has solved the problem of substantially de-ashing coal within commercial limits of as low as 0·5 per cent. He has also induced the Department of Scientific and Industrial Research to make a grant which will enable him, along with Mr. R. P. Fraser, to make a photographic investigation of coal-dust-air explosions under actual engine conditions, so that a more fundamental knowledge of the mode of flame propagation, which can be applied to design problems, can be obtained. This research work will begin in January next. Professor Bone is of the opinion that it is high time that the whole problem should be resolutely tackled by some organisation in this country which will not only have adequate financial resources, but will see the matter through, no matter what critics may say.

L.M.S. Railway 1935 Programme.

THE London, Midland and Scottish Railway Company announces that under an extensive programme of carriage and wagon building which is to be undertaken in 1935, 10,833 new passenger and goods vehicles are to be provided for both express passenger and goods trains. Most of the vehicles, we are given to understand, will be built in the company's own workshops at Derby and Wolverton. The new passenger carriages include 166 vestibule and 315 corridor coaches, and 14 restaurant cars, while, in addition, 100 luggage and parcel vans, 100 covered combination trucks, and 26 other coaches are to be constructed. Provision has been made for the building of a total of 10,050 goods train vehicles, of which orders for 1950 have already been placed with British firms. One of the largest items will be 5000 covered wagons of 12 tons capacity, and many of the other vehicles will be specially designed for the conveyance of different kinds of traffic. These will include 100 20-ton tube wagons, 250 20-ton steel hopper wagons, 20 12-ton traction trucks, 10 20-ton bulk grain vans, and 100 cattle trucks. Of the total above mentioned, 3290 wagons are to be specially designed and fitted for running as express goods trains in order to assist further the speeding up of merchandise traffic.

New Naval and Mercantile Shipbuilding Orders.

SPEAKING in the House of Commons last week, Lord Stanley, the Financial Secretary to the Admiralty, stated that, subject to the settlement of certain points of detail, it had been decided to entrust the orders for the construction of the two contract-built cruisers of the 1934 programme to Scotts Shipbuilding and Engineering Company, Ltd., of Greenock, and to Vickers-Armstrongs, Ltd., of Barrow. The Vickers-Armstrong ship will, it is stated, be built at the Walker Naval Yard on the Tyne, but the machinery will be constructed at Barrow-in-Furness. The cruisers, we understand, are of the "Minotaur" class, with a displacement of 9000 tons and a main armament of 6in. guns. Other smaller orders include a steam tug for the Manchester Ship Canal Company, to be built by Henry Robb, Ltd., of Leith; an 8000-ton deadweight cargo ship, for the United Africa Company, Ltd., of London, to be constructed by William Hamilton and Co., Ltd., of Port Glasgow; and two steam tugs for the Southampton works of the James Dredging Towage and Transport Company, Ltd., which are to be built by Scott and Sons, of Bowling, near Glasgow.

Shipbuilding Employers' Federation.

AT the annual meeting of the Central Board of the Shipbuilding Employers' Federation, which was held in Edinburgh on Thursday, November 15th, Mr. C. S. Swan, the vice-chairman of Swan, Hunter and Wigham Richardson, Ltd., of Wallsend, was elected President for the ensuing year, in succession to Mr. G. Tristram Edwards, of Smith's Dock Company, Ltd. Mr. Maurice E. Denny, of William Denny and Bros., Ltd., of Dumbarton, and Mr. F. E. Rebbeck, of Harland and Wolff, Ltd., of Belfast, were re-elected Vice-Presidents; and Mr. F. C. Pyman, the managing director of Wm. Gray and Co., Ltd., of West Hartlepool, was elected Junior Vice-President, to fill the vacancy caused by the election of Mr. Swan to the presidency. Mr. F. C. Mullens, of the Port Talbot Graving Dock and Shipbuilding Company, Ltd., of Port Talbot, was appointed Chairman of the Conference and Works Board of the Federation, with Mr. J. A. Pearson, of Scotts' Shipbuilding and Engineering Company, Ltd., of Greenock, as Vice-Chairman. The meeting reviewed generally the position of the industry and agreed that a slight improvement was shown during the past year. It was pointed out that before work on Admiralty orders and merchant shipping had been begun only about 5 per cent. of the berths in the country were in operation. The middle of the year showed a volume of work which had raised that percentage to 30, but since the completion of much work without substantial new orders the percentage figure had steadily fallen until to-day it was less than 25 per cent. In another paragraph on this page we record some important naval and mercantile orders.

Proposed Traffic Overways for London.

IN an amendment to the debate on the Royal Address, which was presented by a group of Members of Parliament on Tuesday evening last, mention is made of the regret felt at the failure of his Majesty's Government to inaugurate the construction in our great cities of specially elevated thoroughfares for motor vehicles in order to reduce the number of fatalities and casualties upon the streets. A scheme specially referred to is a suggested overway placed, for example, above the main line of the Southern Railway Company between Raynes Park and Lambeth Bridge, which, it is claimed, would accommodate much of the traffic to and from the Great West Road. It is suggested that the overway should consist of two 20ft. carriageways with substantial kerbs, both at the centre and the sides, where there would also be strong balustrades. The British Steelwork Association has collaborated in the preparation of the scheme, and it considers that the 8¼-mile stretch from Raynes Park to Lambeth Bridge could be built without insuperable engineering difficulties at an estimated constructional cost of about £3,000,000. Among the advantages claimed for such overways are their low cost, the speeding up of traffic, the freeing of streets from traffic, the fact that no purchase of property is necessary, and that ribbon development is not involved. The hope is expressed that, after the proposal has been raised in the debate, the Government may see fit to appoint a committee to examine it.

The Surface Condenser.

No. XIV.

(Concluded from page 492, November 16th.)

Pressure Distribution.

IN a modern condenser the drop in pressure of the steam as it passes over the tubes from the turbine exhaust passages to the surface of the condensate is seldom very large. The real trouble is that the existence of any drop in pressure at all is incompatible not only with recorded instances of the condensate temperature exceeding that corresponding to the vacuum, but also with a condensate temperature merely coincident with that of the steam at exhaust. This anomaly has existed ever since the first "regenerative" surface condenser was constructed and to-day it is accepted that it does exist, and attempts at explanation are seldom made.

Other than by condenser trials, the theory of the state of a liquid in contact with its vapour has never been seriously challenged. It is therefore not unreasonable to suspect that the continued unexplained existence of the anomaly lies in the inaccuracy of test results. Nor is it difficult to show that many of the readings observed even in the most careful of trials are unreliable guides. The tacit assumption is not infrequently made that, since steam is a gas, its pressure when it fills the steam space of a condenser will be the same or very nearly the same at every point. Consequently in some convenient position a single mercury gauge is fitted by means of which the vacuum may be observed. That the assumption is totally wrong has been proved on many occasions. In an earlier article of this series there was described a test, carried out by the English Electric Company, Ltd., to determine how the pressure of the steam was distributed around the inlet branch of a condenser. The results of the test are reproduced again in Fig. 56.

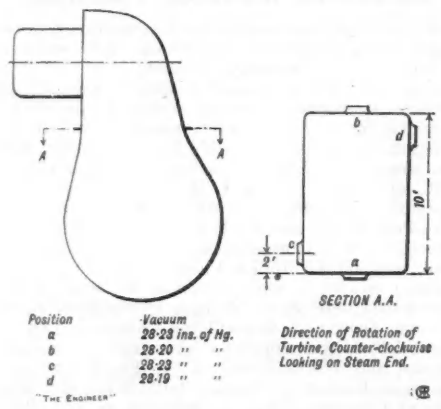


FIG. 56—PRESSURE DISTRIBUTION

Pressure was measured at four separate points and the greatest difference found was 0·04in. of mercury. In a high vacuum plant that variation is equivalent to about 1 deg. Fah. of temperature. A more complete investigation of the distribution of pressure in the exhaust branches of a turbine is to be found in the pages of the *V.D.I. Zeitschrift* of 1927. The article is obtainable as a reprint in English from Escher, Wyss Engineering Works, Ltd. Dr. Stodola, of Zürich, undertook the test of an 11,000-kW "Zoelly" steam turbine, and in order to determine the mean exhaust pressure took readings of the vacuum by means of accurate mercury gauges at a number of points distributed over the walls of the exhaust passages. The results he obtained are reproduced in the following table and the positions of attachment of the mercury columns are indicated in the diagram Fig. 57.

Observation point	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
At 10,500 kW output, in. Hg abs.	2·140	2·020	1·831	1·666	1·604	1·659	1·706	1·477	1·674	1·740	1·496	1·690	1·494	1·591	1·551	1·532	1·490	1·670
At 8000 kW output, in. Hg. abs.	1·639	1·678	1·441	0·969	1·154	1·221	1·210	1·051	1·181	1·240	1·071	1·282	1·434	1·111	1·082	1·051	1·015	1·170

At full load the greatest variation was 0·663in. of mercury between points 1 and 8. Both these points are situated close up against the final wheel of the turbine, where the conditions must naturally be very disturbed. Even at entry to the condenser, however, after the steam flow has had time to become more regular, the pressure ranges from 1·591in. at point 14 to 1·490in. at point 17, a difference great enough to be equivalent to more than 2 deg. Fah. of temperature.

In reply to the written discussion of their paper,* Messrs. Guy and Winstanley gave the results of tests carried out by the use of tubes with static tips to determine the variations of pressure over a large area at inlet to a condenser. The diagram Fig. 58 shows the position of the points and the variation in pressure in inches of mercury. The average vacuum was 29·097in., the maximum 29·165in., and the greatest variation as much as 0·232in., equivalent to 7·5 deg. Fah. of temperature!

The flow of the steam becomes no more regular among the tubes of the condenser, as individual tube heat transmission tests can demonstrate. In one such test on a Metrovick radial flow condenser there were recorded for two tubes on the outer side of the outer bank on the alternator side of the shell values of K_t of 2700 B.Th.U. and 2240 B.Th.U. per square foot per degree Fahrenheit per hour respectively. For two other tubes situated in similar positions on the turbine side of the shell the values of K_t were only 1920 B.Th.U. and 950 B.Th.U. respectively. In a more direct investigation of pressure distribution carried out by the English Electric Company, Ltd., it was found that as between the side and end of a condenser there was a difference of pressure of 2in. of water at no load and 0·5in. of water at full load.

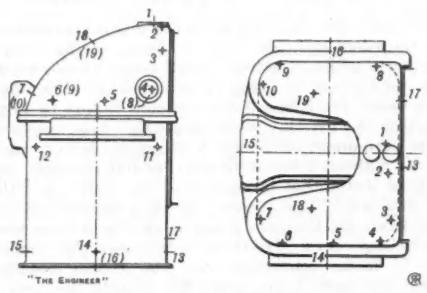


FIG. 57—POSITIONS OF ATTACHMENT OF GAUGES

But although all these figures were obtained as the result of very carefully conducted tests, it is perfectly legitimate to doubt whether they give more than a vague shadowy picture of the real state of affairs. In every case where the pressure was measured directly (except that mentioned by Messrs. Guy and Winstanley) the reading was obtained by connecting a mercury or water gauge to holes drilled through the casing. The pressures recorded are therefore only those of the steam which is flowing up against the casing. The steam is moving at high velocity and there may be an eddying action owing to friction with the containing walls; and the walls may be at a temperature appreciably different from that of the steam. It is therefore very doubtful, to say the least, whether the results obtained are at all representative of the conditions further within where the steam is flowing along a less hampered course. It is as though an attempt were made to gauge the average flow of a deep river by taking readings with a Pitot tube at a series of points arranged close along the bottom and beside the banks.

Temperature Distribution.

Measurements of the temperature of the vacuum space must be regarded with even less trust than that with which the readings of mercury gauges can be accepted. The steam at entry to the condenser is nearly always wet, and amongst the tubes necessarily so. Consequently, any variation of pressure must be accompanied by a change of temperature. Isolated readings of temperature are thus subject to the same errors as those of pressure. Moreover, the readings of a thermometer in the steam space are very liable to be misleading, unless stringent precautions are taken. Of course, the insertion of a thermometer into a pocket in the shell merely gives a reading of the temperature of the shell, which may be, and probably is, quite different from that of the steam. But even when a thermometer is so placed that its bulb is not in contact with the walls it is by no means a reliable instrument. Radiation from the surrounding metal may be more effective than conduction from what is, after all, a highly tenuous gas. In testing an air pump maintaining a vacuum in a dummy condenser supplied with water, a glass thermometer was so arranged that its bulb was situated approximately in the centre of a 6in. air suction pipe. If the quantity of cooling water flowing through the tubes of the air ejector were much reduced, the body of the device grew hot and heat was transmitted along the air suction pipe. Under such conditions the thermometer recorded a temperature very much in excess of that corresponding to the vacuum which the air pump was maintaining.

For only one reading of temperature on the steam side of a condenser can any claim for accuracy be made. The conditions immediately above the surface of the condensate within the shell may be very disturbed. At one point the pressure may be low so that the condensate is boiling furiously, and at another the pressure may be high and the swirling steam may be actually condensing on the water. But in the extraction pump suction pipe the water from all parts of the condensate sump is mixed together so that, if proper precautions are taken, a mean temperature may be observed. It is no longer the temperature of a tenuous gas that is being measured, but that of a liquid with a high specific heat, and the reading can be regarded as an accurate representation of the condition of the condensate within the condenser. It is even possible to go further. Is it not preferable to regard this temperature as a measure of the average steam conditions at the bottom of the condenser rather than to accept the very doubtful evidence of the mercury column, and claim that the condensate has been "reheated" above the vacuum temperature?

Rate of Heat Transmission as a Criterion of Performance.

Many attempts have been made to find some criterion by which condensers operating under widely differing conditions can be compared, and though several formulæ have been suggested we cannot find that any has been adopted with enthusiasm. At the present time the calculated overall rate of heat transmission K expressed in B.Th.U. per square foot of cooling surface per degree Fahrenheit difference of temperature per hour is probably regarded as the best criterion available. But it has many deficiencies in this respect.

The transmission of heat from the steam to the cooling water takes place in three stages. About K_s, the rate of heat transmission from the steam to the tube, not very much is known. In individual tube heat transmission tests its value has been recorded as high as about 3000 B.Th.U., and as low as nil, the latter value obviously being due to the fact that no steam reached the tube. It is, possibly, variable with temperature and, certainly, with the external state of the tube. The British Electrical and Allied Industries Research Association has recently been engaged upon a research into the variables involved and their effects, and it is to be hoped that a report upon its findings will be published. The value of K_t, the rate of heat transmission across the tube wall, is so high in comparison with the others that even the variation in conductivity as between one metal and another is not of great importance in the design of a condenser. In a previous article of this series the variations of K_w, the transmission rate from tube to water, with water velocity and with temperature, were examined. As a result of the work of Eagle and Ferguson they are fairly accurately known. The overall rate of heat transmission is compounded of these three separate variables according to the formula:

$$\frac{1}{K}=\frac{1}{K_w}+\frac{1}{K_t}+\frac{1}{K_s}$$

Since both K_w and K_s vary according to the conditions under which a condenser is operating, the value of K cannot be adopted as a criterion of performance without making due allowance for the conditions. In a condenser holding a low or medium vacuum, for instance, the mean temperature of the cooling water is usually high. It is known definitely that in these circumstances K_w will be high, so that it is to be expected that the overall rate of heat transmission attained will be greater than that of a plant holding a higher vacuum at a lower temperature.

In Fig. 59 there are plotted as a graph the full-load values of K from a number of different plants by different makers against a base of vacuum. The values of the rate of heat transmission were calculated for this purpose by means of the simplified Grashof formula, and no attempt has been made to correct for different velocities of water flow. At

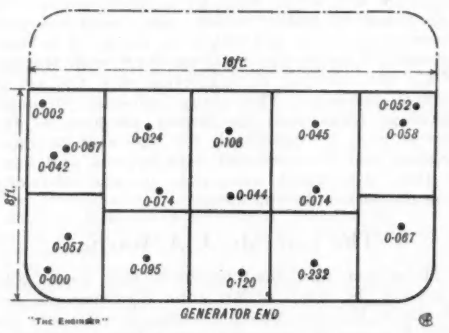


FIG. 58—VARIATION OF PRESSURE

* "Some Factors in the Design of Surface Condensing Plant," Proc., I. Mech. E., 1934.

first sight the points seem much scattered. But by making an arbitrary distinction between condensers with more or less than 25,000 square feet of cooling surface a certain order is seen to grow out of the apparent chaos. It is even possible to draw through the points representing the smaller plant a line relating K and the vacuum, although no suggestion can be made that this line is necessarily the correct one. The number of points is far too small to justify any such temerity. This line indicates a reduction of the value of K as the vacuum is increased. If a true mean position for it could be found it might form a suitable criterion for the comparison of condenser performance. Unfortunately, however, most condenser manufacturers have found that points plotted on a graph in this manner for a large number of condensers are so scattered that it is impossible to reach any definite conclusion as to the location of the line. The points we have taken are those of the test results which have been supplied to us by a number of different manufacturers. The points representing the larger plant are more indefinitely scattered. It is, however, significant that, with the single exception of one which lies very close to the line relating to the smaller condensers, each of the points is below that line. This fact bears out the claim that it is more difficult to obtain high rates of heat transmission in large plant than in small.

It will probably have been noticed that in the drawing out of the graph just discussed only the values of K at the full-load condition were taken. This choice was made for a definite reason. Strangely enough the value of K, as calculated, is variable with the load on the condenser, and is, moreover, variable in different ways according to its design. In Fig. 60 that none, or, at least, very little, is condensed upon the rest. In these circumstances the use of the full value of A in the equation will give an erroneous impression of the value of K, which will be calculated smaller and smaller as the load is reduced. The "rising" characteristic curve A is thus accounted for, and it may be assumed, as far as the "constant" characteristic B is concerned, that over the range of load covered by the graph the whole of the surface is taking its share in the condensation of the steam. But the supposition does not help to explain the "falling" characteristic C.

The only remaining factor in the equation by which the value of K is calculated is t_m, the mean temperature difference. The simplified Grashof equation was used for the calculation of t_m, and it was shown in an earlier article that when the pressure drop in a condenser is high, this equation tends to give too large a value to t_m. Thus, this use of the Grashof equation might account for the existence of a "falling" characteristic if the pressure drop were assumed to increase rapidly with the load. But it is doubtful whether, except under very unusual conditions, it could account for a change from 1000 to 650 B.Th.U. per square foot per degree Fahrenheit per hour while the load altered from 50 per cent. to 120 per cent. full.

The value of t_m depends upon three temperatures—that of the steam at entry to the condenser, and those of the cooling water at inlet and at outlet from the condenser. The accuracy of the measurement of the two water temperatures is open to question, but a check upon them is provided by the fairly accurately known quantity of heat to be removed from the steam in condensing it. But, as was demonstrated earlier in this article, the measurement of the temperature of the steam is liable to very important errors, and cannot be trusted. Instead of the steam temperature the more accurately known condensate temperature can be used for the calculation of t_m on the assumptions that the steam temperature is the same as that of the condensate, and that it does not alter in passing across the tubes. The result of using this temperature for the calculation of K is shown by the graph, Fig. 61. The same three condensers are concerned. But whereas the "rising" characteristic A is practically unaltered, changes have taken place in the others. The "constant" characteristic B has become a "rising" one, and greatest change of all, the "falling" characteristic C, has become a "constant" one with a suggestion in the situation of the first point that at lighter loadings K would be found to rise with the load. In fact, all three curves have become more or less similar in form.

The change of form is particularly interesting in the case of the "falling" characteristic. For if the original curve, Fig. 60, be extended to smaller loadings, it seems that the calculated value of K is going to exceed 1000 B.Th.U. by a very considerable margin. It is difficult to believe that such high values of K are really obtainable. The suggestion implied by the change in the nature of the curve when condensate temperature is used for the calculation of K, is that the mercury gauge happened to be connected to the exhaust flange of the turbine at a point where the absolute pressure of the steam was low, so that the corresponding steam temperature was taken at too low a figure.†

One further point deserves notice before this survey of K and its modes of variation is brought to a conclusion. At the full-load condition the "rising" characteristic A shows no signs of reaching a maximum. If our interpretation of the "rising" characteristic is correct, this continuation of the slope beyond the full-load point can only indicate that there still remains some cooling surface upon which steam is not condensing, and that, therefore, the full-load calculated value of K is less than the real value of the rate of heat transmission of which the condenser is capable. To put the matter in another way, the designers of the particular condenser concerned have probably provided a margin of redundant area to meet the possibility of fouling of the tubes.

The Re-compression Effect.

It will have been noticed that in a great deal of the foregoing discussion, and especially in the calculation of K, the assumption has been made that the average conditions at the top of the condenser are identical with the average conditions above the surface of the condensate. This assumption has been made because no really trustworthy evidence exists as to the real average conditions at the top of the condenser. Any attempt to allow for a change in the conditions may introduce errors as great as those it is hoped by this action to avoid. Many experiments have been made with U tubes connected between the top and bottom of the condenser. High positive drops in pressure; small positive drops in pressure; and small negative drops in pressure have been observed. But if a straightforward measurement of pressure cannot accurately be made by means of a mercury gauge attached to the side of the shell it follows that these experiments with U tubes are likely to give results just as misleading. It seems only reasonable to suppose that there must be a drop in pressure as the steam passes through the tube nests, but the evidence

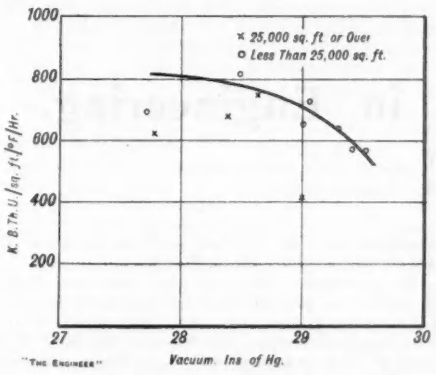


FIG. 59—RELATION BETWEEN K AND VACUUM

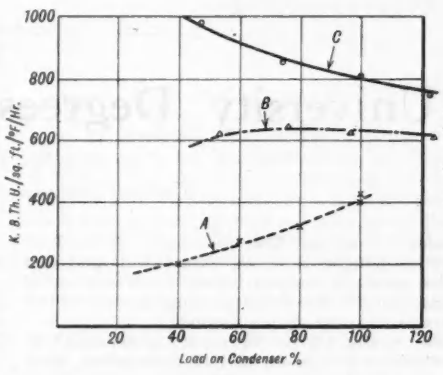


FIG. 60—K-LOAD GRAPH BASED ON STEAM TEMPERATURE

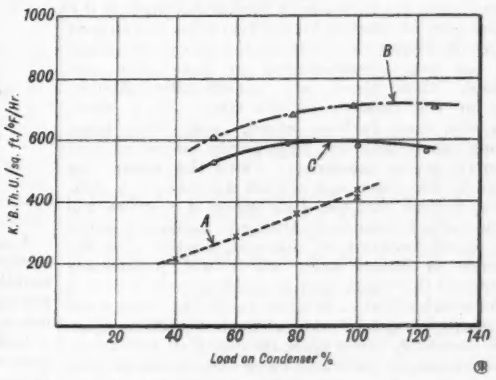


FIG. 61—K-LOAD GRAPH BASED ON CONDENSATE TEMPERATURE

there are plotted curves relating the values of K, calculated by the Grashof simplified formula, with the load for three condensers made by different firms. The lowermost curve, A, is taken from a plant holding a vacuum higher than those held by the other two and, consequently, smaller values of K are to be expected. One of these curves shows K falling with increase of load; the second indicates that K is practically constant, and in the third K increases with load.

But it is very surprising to find that there is any variation of K at all. *Prima facie* it would be natural to expect that K would remain nearly constant regardless of the load, and that its value would depend only upon the efficiency of the tube plate arrangement. Certain minor variations might be expected if the amount of cooling water flowing were altered, or as a result of changes in the vacuum held as the load was altered. But a change from 200 B.Th.U. to over 400 B.Th.U. in the one case, and from 1000 B.Th.U. to 650 B.Th.U. in the other, cannot be explained in this way. The value of K as calculated is very sensitive to errors in the test readings, and cannot be trusted within 5 per cent. either way. But these curves are altogether too regular to be accounted for in any such straightforward manner. They appear to bear some relation to the actual tube plate arrangements of the plants concerned.

It may, however, be worth while to examine whether any systematic error is likely to occur in calculating K. The formula from which K is calculated is:

$$K = H/At_m$$

in which H is the total heat in the whole of the steam condensed per hour in B.Th.U.; A is the total cooling surface in square feet, and t_m the mean temperature difference between the steam and the cooling water in degrees Fahrenheit.

No systematic error is likely to occur in the value taken for H. The amount of steam condensed is usually known fairly exactly, and the heat to be removed to condense it can be calculated pretty closely.

The surface area of the cooling tubes appears at first sight to be an invariable quantity. But it is easily possible to conceive that at the lighter loads the whole of the steam may be condensed on those tubes with which it first comes into contact, and

† It is only fair to note at this point that the manufacturers of the plant concerned claim that the reason for the "falling" characteristic is the arrangement of the tube plate, which is such as to be particularly free from air blanketing. At heavier loadings the rate of condensation per square foot becomes so high that partial water blanketing takes place, with a consequent reduction in the value of K. The particular condenser under discussion is the only one for which test results have been sent to us that exhibits this "falling" characteristic. It would be interesting to know whether in all plants having a similar characteristic the use of condensate temperature would "correct" it into a constant or a rising one.

so far put forward is inconclusive. The Mirrlees Watson Company, Ltd., can, for instance, point to a number of tests in which results similar to those recorded in Table XVII have been obtained. A pressure rise, it will be seen, averaging 0·032in. of mercury was observed. The possibility, therefore, still remains that a condenser may be so constructed that the kinetic energy of the entering steam may be converted into pressure energy at the surface of the condensate. The supposition does not require that the whole of the steam be re-compressed, but only that part of it which reaches the condenser bottom uncondensed. Since in such circumstances the condensate, without being "re-heated" in antagonism to theory, could be removed at a temperature higher than that of the steam at exhaust the subject needs investigation. If, as The Mirrlees Watson Company claims, it is possible to obtain the effect, no condenser in which it does not occur can be regarded as having a high efficiency, even though the actual thermal saving is small.

Conclusion.

Those who have been sufficiently interested to read the whole of the articles in this series must surely have been struck by the extraordinary variety of tube plate arrangements adopted by the various condenser manufacturers. This variety is not forced upon them by external factors, such as those which influence the arrangement of sub-base or other special designs, but has, in each case, been adopted in the belief that some special advantages have been gained. Without mentioning "Inverted" and "Radial Flow" designs, there is among "Downflow" plant alone a strangely wide variety. The Weir condenser has one large central steam lane; the Contraflo a number of lanes converging upon a point just above the condensate; and both depend for regenerative effect upon the play of uncondensed steam over the surface of the condensate. In the Mirrlees design the tubes are arranged as a group of vees and the English Electric arrangement provides special air lanes besides steam lanes. In neither can the steam reach the condensate without passing through a part of the tube nests. It is, no doubt, probable that in a device like a condenser, upon the design and operation of which a number of partly external matters have an influence, several forms of tube plate arrangement may be, not perhaps equal in efficiency, but of equal merit from the point of view of the purchaser. But so wide a variety

suggests that manufacturers are still searching by a laborious method of trial and error for a tube plate arrangement which will give the best possible results in service without too great an expense of operation or in construction. The requirements are well known. Air and other incondensible gases must be rapidly and easily removed; steam must, without difficulty, reach every tube; the resistance to its flow must be as small as possible; and the condensate temperature must be at least as high as that of the exhaust steam. It is in the method to be employed to meet these requirements that the manufacturers differ. The variety of tube plate arrangements devised by designers is merely a demonstration of the fact that little is known about the manner in which the steam reaches and is condensed upon the tubes, and that the greater part of what is known has been determined as a result of experience with the less successful plants.

It has been demonstrated on more than one occasion that there are considerable fluctuations in the pressure of the steam as it flows from the final turbine wheel, and that these pressure variations are only partly smoothed out at entry to the condenser. Once the steam has begun to flow over and around the tubes it is difficult to believe that the distribution of pressure will not be further disturbed. Owing to variations in the rate of condensation in different localities, to the presence of steam lanes which will presumably "attract" the steam, and sometimes to the effect of baffles which will alter its direction of flow, there must necessarily be violent eddies. Such conditions again must inevitably react upon the rates of heat transmission attained and make more difficult the correlation of researches conducted under laboratory conditions with the performance of actual plant in service. Nor, at present, is it possible to calculate K with any great accuracy. Its value depends so largely upon the mean temperature difference between the steam and the cooling water that any error in the measurement of the steam temperature can lead to wide divergencies. For the calculation of the mean temperature difference it is necessary to assume some regularity of steam pressure distribution where little regularity exists. The full Grashof formula assumes that the temperature of the steam varies proportionately with the heat given out, an assumption hardly tenable for steam which may condense at constant temperature and whose temperature is in any case largely controlled by pressure conditions. A more consistent result is probably attainable by the use of the simplified formula which makes the assumption that the steam temperature remains constant, although in view of the certain fact that it varies it is difficult to know exactly what steam temperature to adopt as the mean. As was demonstrated earlier in this article by the K-load graphs, wide changes may be brought about according to the value of steam temperature adopted. Although the "crossflow" formula due to Dr. D. M. Smith is undoubtedly founded upon assumptions more closely related to the actual conditions, Mr. Guy, who himself puts forward its advantages, is fain to admit that it probably exaggerates the effect of pressure drop. In fact until the actual pressure distribution within a condenser becomes predictable and known it is difficult, if not impossible, to make assumptions upon which a formula may be founded. If, as has been suggested, for instance, the greater part of the drop in pressure—the existence of which, by the way, is a matter of some dispute—occurs among the first few rows of tubes, then the assumptions upon which a formula for temperature difference are founded should take account of the fact. Like Mr. S. S. Cook, of C. A. Parsons and Co., Ltd., many people may be disposed to doubt whether, at present, any advantage is to be gained by the use of any formula except that due to Grashof, simplified, and used, not with the steam temperature at entry, but with a mean steam temperature chosen from experience with the plants concerned.

In recent years much research has been carried out with the object of discovering the laws of heat transmission through tubes. By the publication in 1930 of the results of a research conducted by Messrs. Eagle and Ferguson for the British Electrical and Allied Industries Research Association, dealing with the rate of heat transmission from tube to cooling water, much that had previously been doubtful was placed upon a sounder footing. Recently the same Association has investigated the allied problem of the transmission of heat from the steam to the tube and the results have, we believe, been communicated to the member firms. It is much to be hoped that in due course they may be published. Condenser designers are now therefore in possession of a large amount of information with regard to the essential facts of heat transmission, although, no doubt, much yet remains to be done. The value of the work will be felt when time has been given designers to correlate the research results with the performance of actual plants in service. But the study of heat transmission is only one part of the problem. When everything has been done to increase the rate of heat transmission from the steam to the water it will still be necessary to ensure that each tube is receiving its quota of steam to condense and that no undue resistance to the passage of the steam is provided by the tube banks. The next step, therefore, seems to lie in the study of steam distribution, so that an arrangement of the tubes can be devised which will not only give free access of the steam to every tube, but which will also be such that the pressure distribution is predictable and known. If and when that stage is reached the design of the surface condenser will have closely approached finality.

TABLE XVII.—*Test of Mirrlees-Delas-Ginabat Condenser at Kelty, 24/3/39.*

Duty, 70,200 lb. steam per hour at 28·25in. vacuum (bar. 30in. Hg.). Cooling water, 8540 g.p.m. at 75 deg. Fah., two water flows. Condenser friction, 10·5ft. water velocity 7ft. per second. Condenser surface, 6360 square feet, 2789 tubes, ¾in. O.D. × 11ft. 8in. between tube plates by 18 S.W.G.

Steam load corrected.	Condenser readings corrected.							Condensate.		Circulating water.					M.T.D.	Heat trans. rate, B.Th.U. per square foot per deg. Fah. hour.
	Top.			Pressure rise.*	Bottom.			Temp. at ejector inlet.	Temp. at ejector outlet.	Inlet temp.	Outlet temp.	Temp. rise.	Quantity.	Velocity.		
	Vacuum.	Temp. measured.	Temp. calculated.		Vacuum.	Temp. measured.	Temp. calculated.									
Lb./hr.	In. Hg.	Deg. Fah.	Deg. Fah.	In. Hg.	In. Hg.	Deg. Fah.	Deg. Fah.	Deg. Fah.	Deg. Fah.	Deg. Fah.	Deg. Fah.	Deg. Fah.	G.p.m.	Ft. sec.	Deg. Fah.	
58,800	28·68	88·0	87·45	0·040	28·64	88·3	88·39	87·2	98·6	68·1	81·1	13·0	7540	6·18	11·80	783
58,800	28·66	88·8	87·93	0·026	28·63	88·9	88·53	88·6	98·6	68·8	81·9	13·1	7480	6·14	11·40	810
58,800	28·62	89·1	88·85	0·032	28·59	89·1	89·59	88·8	99·1	69·8	82·1	12·3	7970	6·54	11·58	799
58,800	28·60	89·4	89·31	0·029	28·57	89·5	90·00	89·6	99·6	70·0	82·6	12·6	7780	6·38	12·00	770
58,800	28·64	88·83	88·39	0·032	28·61	88·95	89·13	88·55	98·98	69·18	81·93	12·75	7693	6·31	11·70	790·5

* Measured direct on U tube.

University Degrees in Engineering.

No. IV.

(*Continued from page 489, November 16th.*)

London University.—The constitution of the University of London is of an exceptional kind and requires some explanation before the true place of the University in the educational organisation of this country can be properly understood.

Under its statutes the University is required "to hold forth to all classes and denominations, both in the United Kingdom and elsewhere, without any distinction whatsoever, an encouragement for pursuing a regular and liberal course of education; to promote research and the advancement of science and learning; and to organise, improve and extend education of a University standard." This wide definition of the purpose of the University provides a key to the understanding of its organisation. It will be gathered from it, for instance, that the scope of its activities is not restricted to the local needs of London but embraces the whole of the British Empire and even the whole of the world. Most of our universities attract students from beyond their own districts and even from beyond our own shores but, with the exception of Durham which has affiliated colleges in Barbadoes and Sierra Leone, all, outside London, confine their activities and privileges to establishments and institutions within their own districts. London's "district" is, by statutory definition, the whole of the world and in practice covers the British Isles and many parts of our overseas Empire. In effect any teaching establishment, wherever situated, which aims at providing education of a university standard or any individual who, by any means, desires to acquire such education may claim the encouragement of London University and, on fulfilment of prescribed conditions, it or he will be admitted to the privileges of the University.

Again, it will be noted from the statutory definition that the University is not specifically required to conduct instructional classes or courses. It is sometimes supposed that King's College, Strand, and University College, Gower-street, constitute London University or at least the heart of it. This supposition is wrong. The University of London is situated at South Kensington. It does not conduct any teaching but exists as the central government of a federal body of teaching institutions or schools. Among these schools are King's College and University College. They are exceptional as schools of the University only in so far as they are particularly closely governed by the central body but other establishments, such as the City and Guilds (Engineering) College and the East London College, although each has a separate governing body, are, equally with the two Colleges, schools of the University. They have acquired that status by agreeing to conform in certain respects to the statutes of the University. There are other educational establishments, such as a number of the polytechnics in the London area, which are linked to the University less completely than the schools. At these establishments, known academically as institutions, the University has recognised not the establishment as a whole but only certain teachers engaged at it.

The University, while of itself not undertaking the instruction of students, co-ordinates the activities of its teaching members and determines what is to be taught at them. Further, it is the body which conducts the examinations of students preparing for a degree and it alone grants degrees.

All students following a prescribed course of study for a degree at a "school" of the University or under a recognised teacher at an "institution" are registered as internal students and may qualify for an internal degree.

Outside this organisation for the training and examination of internal students the University has an almost equally large organisation whereby it extends encouragement and privileges to many students who do not or cannot attend one of its "schools" or "institutions." These external students as they are called may, after they have registered themselves as such, take the examinations provided for them by the University and may thereby qualify for an external degree. The regulations for external students leave each student free to select his own means of acquiring the education necessary to enable him to pass the examinations. He may, if he so desires, pursue his studies entirely in private without attending any classes at an educational establishment. So far however as students of engineering are concerned the necessity for a knowledge of laboratory work practically excludes the possibility of anyone preparing himself satisfactorily for the degree examinations entirely by private study. In any event even if such a possibility exists to-day it will definitely disappear in and after 1936. After that date a regulation will come into force which will require all candidates for an external degree to submit certified evidence that they have carried out a course of work at an approved college or institution. It may therefore be said that at present probably all students preparing for an external engineering degree of London University are obtaining some or all of their instruction by attending, either during the day or in the evening, courses at some teaching establishment and that in about a year's time it will be compulsory for them to do so.

A notable example of the use made of London's external degree organisation is provided by the case of Nottingham University College. That College, as already noted, does not grant any degrees of its own but prepares its students for the London external degrees. Its three-year engineering course for the ordinary or honours B.Sc. external degree is in all respects comparable with the like course provided at King's or University College, London, for internal students. Southampton University College and corresponding establishments at Exeter, Leicester and Hull follow the same plan. At one time before they obtained full university status and became empowered to grant their own degrees the Univer-

sities of Manchester, Leeds, Liverpool, Sheffield, Bristol and Reading used the examinations of London University in the same manner.

At the last census of students of London University there were nearly 13,000 internal and over 12,000 external students. About two-thirds of the external students were studying at university colleges, technical schools or other teaching institutions in London or the provinces. The remaining third were studying privately or were resident in the Empire overseas. These figures cover all faculties. Among the private students the bulk or the whole would of necessity be students of theology, arts or other subject lending itself to private study. Few or none of them could have been engineers.

In the Faculty of Engineering the University of London grants the degrees of B.Sc. in Engineering, B.Sc. in Engineering (Mining), B.Sc. in Engineering (Metallurgy), M.Sc. in Engineering, Ph.D. and D.Sc. in Engineering. In what follows we summarise the regulations for internal students proceeding to the B.Sc. degree. This summary may be taken as being applicable to courses of instruction pursued at any of the "schools" of the University or under recognised teachers at an "institution." The survey has of necessity to be of a more general character than in the case of other universities in view of the varying customs and practices followed at the different schools and institutions.

The course for internal students in the Faculty of Engineering is normally divided into two stages which lead to the intermediate and final examinations respectively. For the first stage the minimum number of hours spent on the required course of study is 360 and in practice this stage is usually completed in the course of a first session covering three terms. The subjects of the intermediate examination are pure and applied mathematics, heat, electricity and magnetism, engineering drawing and either sound and optics or chemistry or geology. An advanced student if he is suitably qualified may be exempted wholly or in part from the intermediate examination and thereby be enabled to save a year of study at the University. Exemption under this head is however given in the Faculty of Engineering only in very exceptional cases. For the second stage, leading to the final examination, the minimum number of hours to be spent on the required course of study is 480. In practice this course of preparation is normally completed in two years of three terms each. The final examination to which this stage leads may be divided into two parts taken at the end of the second and third year respectively. If it is so divided the first part is in the nature of a qualifying examination. The subjects of the final examination are divided into two groups. The first group comprises the theory of machines and machine design, the theory of structures and structural design, the strength and elasticity of materials and electrical technology. The second group comprises the mechanics of fluids, surveying, applied thermodynamics, electrical machinery and design, the generation, transmission and utilisation of electric power, electrical measurements and measuring instruments, telegraphy and telephony, advanced theory of machines and machine design, advanced theory of structures and structural design and mathematics. To obtain an ordinary or "pass" degree a candidate is required to take three subjects from the first group and at least two from the second. To obtain a degree with first or second-class honours a candidate is required to take three subjects from the first group and at least three from the second and in each subject is required to reach a higher standard than that necessary to secure a "pass" degree. If he fails to reach the honours standard he may be awarded the "pass" degree. No candidate is allowed to chose from the second group more than two electrical subjects nor may he take both advanced theory of machines and advanced theory of structures. It will be observed that within this curriculum provision is made for the needs of civil, mechanical and electrical engineers. For the B.Sc. (Engineering) degrees in Mining and in Metallurgy appropriate courses of instruction during the second stage are provided.

The fees charged for the degree course differ at different schools and institutions. At University College and at King's College the composition fee is forty-eight guineas for the first-year course and sixty guineas for the second and third.

The degree of M.Sc. in Engineering is open to Bachelors of Science of one year's standing. Candidates for this degree are required to submit a dissertation which shall be either a record of original work or a critical exposition of existing data on some particular subject within the purview of the Faculty of Engineering. An oral examination and, if required, a written examination or other test have to be passed. If the dissertation is inadequate but of sufficient merit a candidate may be permitted to re-present it in a revised form within a year. The fee payable on entry for the degree is ten guineas.

The Ph.D. degree is granted to graduates who for two years or more pursue in a school or institution of the University a course of training in research and research methods and who submit a satisfactory thesis and take an oral and, if required, a written examination on the subject of the thesis. The subject of the thesis must be declared by the candidate and must be approved by the University one year before the candidate enters for the examination. The greater portion of the work discussed in the thesis must have been done subsequently to the registration of the candidate as a student working for the Ph.D. degree. The thesis is required to be satisfactory as regards literary presentation and to constitute a distinct contribution to the knowledge of its subject. It must show evidence of originality as by the disclosure of new facts or by the exercise of independent critical power. An inadequate thesis of sufficient merit may be revised and re-presented as in the case of the M.Sc. degree. Further if the thesis is adequate but if the candidate fails to satisfy the examiners at the oral or written test the same thesis may be re-presented after a lapse of six months. Candidates may during the two years of preparation for the degree undertake teaching or demonstrating in a college or school of the University for a length of time not exceeding six hours per week. The fee payable on entry for the degree is twenty guineas.

The degree of D.Sc. in Engineering may be awarded to candidates who have already obtained the M.Sc. or the Ph.D. degree in engineering of the University. In exceptional circumstances a candidate who holds the B.Sc. degree may, before being granted the D.Sc., be exempted from taking the M.Sc. or the Ph.D. degree. Exemption is granted on the ground of published work. The qualification for the D.Sc. degree consists of the submission of published papers or books containing original contributions to the advancement of knowledge. Candidates may be required to present themselves for an interview. The fee payable on application for the degree is twenty guineas.

The regulations governing the external B.Sc. degree in engineering are the same as those for the internal degree so far as concerns the subjects of the intermediate and final examinations and the standard to be reached in order to obtain a "pass" or an honours degree. The M.Sc. degree is open to holders of the external B.Sc. degree of two years' standing. The degree is awarded following the submission of a dissertation on an approved subject succeeded by oral, written and practical examination. The dissertation is required to be an ordered and critical exposition of existing knowledge of the subject selected by the candidate. In substitution for it he may submit a thesis recording original work and if this thesis is of special excellence he may be exempted from part of the subsequent examination. The Ph.D. degree is open to holders of the external B.Sc. degree who become internal students and pursue the two years' course and fulfil all the other regulations required in the case of holders of the internal B.Sc. degree. The D.Sc. degree is open to external graduates on the same basis as to internal graduates.

(To be continued.)

The Machine Tool and Engineering Exhibition at Olympia.

No. III.

(Continued from page 479, November 16th.)

Webster and Bennett, Ltd.

THERE are in all five machines on the stand of Webster and Bennett, Ltd., Northey-road Works, Foleshill, Coventry, of which we illustrate two in Fig. 19 and Fig. 48, p. 514, The most novel is a "High Power" boring mill with a 36in. diameter chuck, which will swing up to 38in. diameter by 19in. under the cross slide, and 27in. under the turret. Among its novel features are a flanged motor for driving purposes, and a speed box arranged in the column, which reduces the number of spindle drive gears. The gear shafts have splines machined out of the solid and run on Timken roller bearings. Timken bearings are also used to take up the thrust of the mitre gears. There are indicating dials for the speed and feed

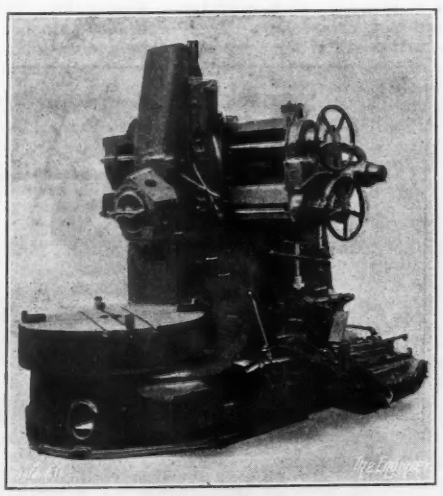


FIG. 19—48-INCH SINGLE MILL—WEBSTER & BENNETT

gear boxes, and the feeds can be changed while the machine is running. A separate motor is provided for rapid traverse motions, and all the principal running parts are automatically lubricated. This machine is also made with a 48in. chuck.

The 48in. single mill which we illustrate in Fig. 19 will swing work up to 52in. in diameter by 24in. under the cross slide, or 35in. under the turret. It is intended for heavy chucking work, and is driven through a V belt by its own motor. It will be noticed that all the control handles are conveniently grouped together. The column is in one casting with the base. The machine shown in Fig. 48, p. 514 is a 36in. vertical turret lathe with two tool slides, one on the horizontal saddle or slide, and the other on the vertical column. The cross slide gives a large rise and fall, and enables tall work to be accommodated, while two cuts can, of course, be made simultaneously. Other machines on this stand comprise a 36in. high-power duplex mill very similar in general arrangement to the single mill illustrated in Fig. 19, but with right and left-hand units connected together. A single mill may be converted to a duplex at a later date by the addition of a left-hand unit, which would be fitted with a reversing motion to the spindle, so that right-hand twist drills could be used. There is also a 36in. rapid-production mill designed for lighter classes of work which may be run at higher chuck speeds.

Tensometer, Ltd.

A complete range of Hounsfield tensometers will be found on the stand of Tensometer, Ltd., of 73, Southampton-row, London, W.C.2. The instruments displayed, together with the various devices arranged for different tests and the automatic measuring of test pieces, were fully described in our articles of February 17th and October 6th, 1933.

We are interested to learn that up to date (that is, within two to three years) some 400 of these small

FIG. 20—TENSOMETER SPECIMEN TAKEN FROM PISTON HEAD

piece testing machines have been supplied to twenty-five countries, and the accuracy of the results obtained has been generally established by Government Departments and by leading manufacturers in the engineering and aeroplane industries. The Tensometer is an instrument which, as we have previously pointed out, provides not only for all tensile tests, but also enables a valuable notch bar test, a Brinell hardness test, a cast iron bending test, and a sheet strip test to be made, all with test specimens of very small size. It will be obvious to our readers from the illustration we reproduce in Figs. 20 and 21 that the small test

piece lends itself admirably to the convenient investigation of the physical properties of materials, whether new, part machined, or completed, while it is invaluable for testing specimens from parts which have failed or show altered physical characteristics under conditions of load. By means of the Tensometer, the supply of incoming material can be easily checked and specification demands upheld. This is particularly necessary in view of the wide range of metals and their alloys which is now available to engineers, if the most economical material for high-duty service is to be chosen and its qualities maintained in service.

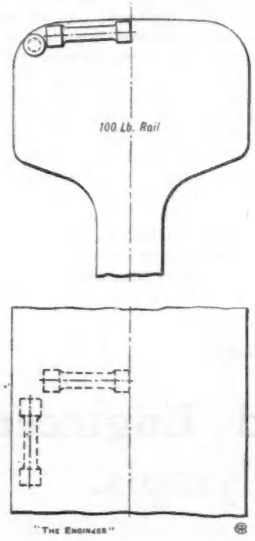


FIG. 21—TENSOMETER SPECIMENS CUT FROM RAIL

In this connection it is of interest to record that Tensometer tests recently enabled the mixed contents of a store bin to be accurately identified and sorted. Other uses will no doubt suggest themselves to our readers.

In Fig. 21 we show the positions of two test pieces which were prepared to compare the qualities of steel in a rail section. The figures given in ordinary type in the table below are those for rail of 0·59 C, 0·83 Mn, free from segregation, while those in italic type are for a badly segragated rail of 0·50 C and 0·69 Mn composition.

It will be readily seen that while a large test piece might have indicated the difference between tests A and B, only the Tensometer with a small test piece could show that between C and D or B and D.

Tensometer test piece from	Longitudinal test pieces.			Transverse test pieces.		
	Brinell	Ultimate tens. sts.	Elong., per cent.	Brinell	Ultimate tens. sts.	Elong., per cent.
Head ..	218	51·25	19	218	50·5	10·5
	187	*45·75*	*23*	*233*	*38·25*	*3*
Web ..	218	51·25	18·5	218	52·25	21
	198	*48·0*	*15·5*	*192*	*42·75*	*19·5*
Foot ..	218	51·25 A	19	218	50·75 C	9
	182·5	*45·25* B	*24·5*	*187*	*27·5* D	*3*

The other illustration, Fig. 20, shows an aluminium alloy piston for an oil engine, for which it was desired to check the continuity of strength properties in the crown, and around the walls and gudgeon pin supporting bosses.

A new type of extensometer which can be used alike on strip and bar is also shown on the stand of Tensometer, Ltd. It has been specially designed for the accurate measurement of yield points and proof stresses on specimens of strip and bar, and has recently been approved by the Mechanical Committee of the British Standards Institution. It is already in general use in the leading engineering firms, and in the laboratories of universities and technical colleges.

As will be seen from Fig. 22, a dial gauge is used. It is fitted with a bezel zero setting, and is mounted on an aluminium base, provided with suitable clamps to hold the strip under test. A system of spring-pivoted levers is employed to transfer the movement of the clamps to the dial pointer, thereby eliminating any possibility of error such as would occur through hinged pivots. This arrangement also has the advantage that it is not affected by continuous use. The levers are so proportioned that one division on the dial (normally indicating $^1/_{100}$ mm.) corresponds to a movement of one ten-thousandth of an inch. The effect of this ability to obtain an indication of an extremely small movement is that while the load applied to the specimen remains within its elastic limit the dial pointer moves slowly and regularly. Immediately this point is passed, however, the movement of the pointer quite definitely accelerates, and continues without the addition of further load. The load at which this occurs cannot be mistaken, and not only is an extremely accurate result obtained, but also a graphical picture of the phenomenon of reaching the yield point—an illustration which is, without question, indelibly impressed on the mind of the observer.

A further advantage of the instrument is that only one person is necessary to operate the testing machine, as the dial is so arranged that its indications are clearly visible while the load is being applied. In order to avoid the necessity of marking out a standard distance on each test specimen, a locking bolt is provided which definitely locates the clamps 2in. apart, and the clamps are furnished with hardened steel balls which ensure a rigid grip without damage. The effect of the clamping arrangement is that the specimen can be immediately placed in the testing machine and the yield point and proof stress obtained in a fraction of the time normally required.

The operating routine to be followed is quite simple; the instrument is clamped on to the test piece with the locking bolt in position. A small initial load is applied to the specimen. The locking

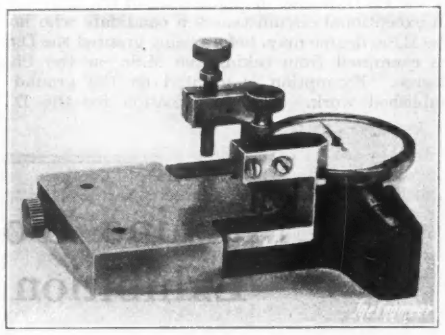


FIG. 22—GERARD STRIP EXTENSOMETER —TENSOMETER

bolt is then withdrawn and the dial set to zero. It is necessary to disconnect the instrument as soon as the yield point and proof stress has been indicated, and before fracture occurs. The instrument we have described, for which Tensometer, Ltd., has been appointed the sole selling agent, was specifically designed for the quick and accurate determination of yield points and proof stresses, and it is not adapted for obtaining stress and strain diagrams within the elastic limit or for demonstrating graphically with any accuracy the elasticity of metals.

H. W. Ward and Co., Ltd.

Capstan and turret lathes are, naturally, the chief exhibits on the stand of H. W. Ward and Co., Ltd., Dale-road, Selly Oak, Birmingham, and some of them are shown in operation. Among them there is the combination turret lathe illustrated by Fig. 23, which has centres 8¾in. high and a bed 8ft. long.

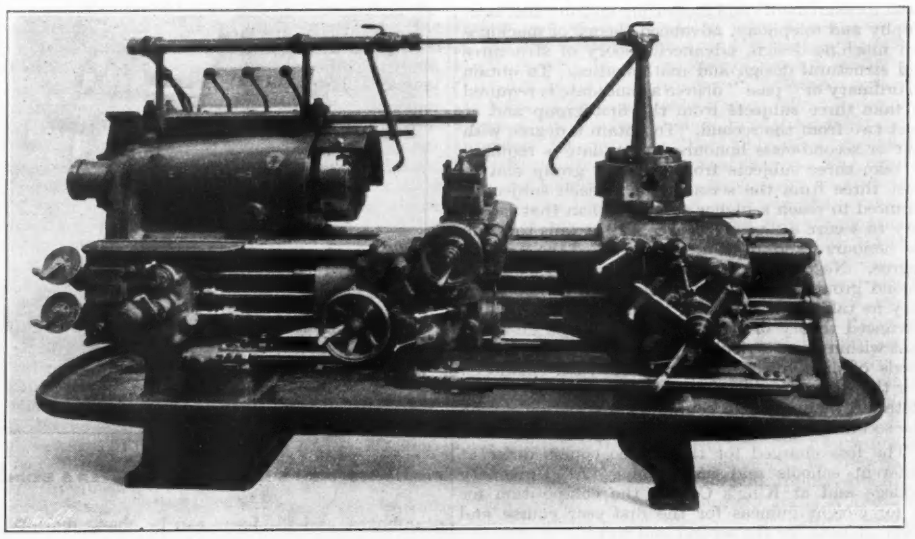


FIG. 23—8¾-INCH TURRET LATHE—WARD

One of the outstanding features of this machine is the arrangement made to protect the working surfaces of the bed from accidental damage and wear. This is effected by covering them entirely with stainless steel sheet guards, which are threaded through tunnels in the saddles. The guards are fixed to the bed at the ends, but do not touch it along their length, but the supporting surfaces for the saddles reach underneath them. There is, consequently, no possibility of swarf or dropped tools damaging the sliding surfaces of the bed. The headstock, as will be gathered from the illustration, is of the "all-geared" type, and gives eight speeds in either direction, which can range from 26 to 536 r.p.m., and from 50 to 1000 r.p.m., according to the speed of the driving pulley. The various ratios are obtained by sliding gears, which are mounted on splined shafts running in ball and roller bearings. The combination of gears required is obtained by means of the levers seen over the top of the headstock. There is a driving clutch of the cone type which is held in engagement when driving by a compression spring, and the gears cannot be changed until this clutch has been opened. A brake is also applied as the clutch is opened. The saddle has automatic sliding and surfacing motions, which can only be engaged one at a time, as they require opposite movements of the same lever. There is, of course, also the screw-cutting movement, by means of the lead screws. The system adopted is to use a series of seven interchangeable lead screws which, in combination with the gear-box, will give all the common Whitworth or metric pitches. The gear-box is driven by a train of wheels from the end of the mandrel, and provides motion to the two feed shafts and to the lead screw. The levers, which can be seen on the left of the illustration, operate sliding spline shafts through gears, and thus provide three changes for the lead screw, ten changes to the sliding and surfacing shaft, and five changes to the turret feed shaft. An independent gear in the turret increases its changes to ten. Eight stop positions are provided for the surfacing feeds—four in each direction—and six stops mounted on a rotatable shaft provide for tripping the longitudinal motions of the saddle. All the stops act as trips for the feeds and as dead stops. The various gears can be changed and reversed while the machine is in motion. There is also an interconnection between the quick-withdraw motion of the screw-cutting tool and the lead-screw nut, so that the two act simultaneously. The turret saddle has a longitudinal travel of 34in. and has feeds suitable for boring, reaming, rough turning, and finishing, without it being necessary to reset the main gear-box. The machine requires a motor of about 7½ H.P. for an independent drive.

Wotan und Zimmermannwerke A.G.

A noteworthy tool on the stand of Soag Machine Tools, Ltd., is the hydraulically operated high-duty shaping machine, which we illustrate in Fig. 42 on page 514. It is made by the Wotan und Zimmermannwerke A.G., of Glauchau, Saxony, and is one of a series of five sizes with ram strokes varying from 23in. up to 39½in. The machine makes use of a hydraulically-operated ram and a hydraulic table traverse, and it is claimed for it that it can compete with the milling machine as a general purpose tool. It is especially adapted for high outputs, giving, it is claimed, low tooling costs and short setting up times and machining times. One of the hydraulic shaper tests recently carried out showed a removal of stock amounting to 176 lb. per hour from a block of Siemens-Martin steel having a tensile strength of 41 tons per square inch, which, it must be admitted, is a good performance. The shaper exhibited is driven by an electric motor housed in the body of the machine, which is coupled directly to the pressure pump. The ram slides on flat guides, which are adjusted by means of a trapezoidal strip. It is served by a hand-operated lubricator, and under the ram in a direct line with the tool holder the hydraulic cylinder is placed. By sub-dividing the cylinder on the pressure side high return speeds can be attained. For keeping the tool in good condition a speed not exceeding 50ft. per minute when roughing is recommended. For finishing cuts with a higher speed a smaller section of the cylinder is used, but the ram reverse is unaltered. When desired, the tool holder head can be equipped with an automatic vertical feed, with automatic disengaging gear in both directions. The ram reversing, it has been shown, is so exact that an overrun of only 0·8in. is sufficient, so that when shaping close against

a shoulder a small recess of 0·8in. to 0·12in. in width is all that is necessary. The operation of the machine is very simple and all the necessary controls are conveniently grouped at the right-hand side as shown in Fig. 42 on page 514. They include levers for engaging and disengaging the ram and the table traverse, also a rapid table traverse for setting up stops for regulating the stroke of the ram, and a lever for varying its speed up to 50ft., 72ft., and 100ft. per minute while the machine is running. The table is very rigid in its construction and it moves on flat sliding surfaces, while a strong stay in the front is also provided. It can be traversed automatically at feeds between 0·01in. and 0·26in. per double stroke, or can be used with the quick setting up movement. The cutting speed of the machine is independent of the lengths of stroke, so that the machine can always work at the most appropriate speed. When overloaded, a safety valve automatically releases the oil pressure, thereby guarding the machine against possible damage.

Another Wotan tool shown on the Soag stand is the high-efficiency R.J. 30 internal grinding machine, illustrated in Fig. 43 on page 514. It is furnished with a hydraulic table drive, and a hydraulic grinding wheel feed, while the work spindle is automatically stopped and the hydraulic power turned off as soon as the table has reached its end position. The machine is equipped for direct motor driving, and a semi-automatic work measuring device, which has been designed and constructed under German and foreign patents, forms part of the equipment. The dial of this device will be seen immediately above the large hand wheel to the right of the machine at the front. The indicator on the dial shows when the grinding wheel must be dressed by the truing diamond, the arrangement being such that the reduction of the wheel when trued is automatically compensated by the measuring device so that the measuring accuracy remains unchanged no matter how frequently the grinding wheel is dressed. The machine is constructed to grind short or long cylindrical or tapered work either through or blind, or with castellated or plain bores. The general stiff box-like structure of the base and principal parts is clearly shown in Fig. 43. The table is of large section with ribbed reinforcement, and it carries the hydraulic cylinder within it. The work head can be swivelled about 10 deg. for grinding taper bores.

The feed may be operated by hand or automatically, and the automatic feed is adjustable with reference to the diameter from 0·00004in. to 0·00028in. per stroke of the table. A movement of one division of the scale of the hand wheel corresponds to a feed of 0·00004in. For setting up the table can be quickly traversed by means of a hand wheel. When operated by hydraulic means a range of from 3ft. to 50ft. per minute is available in stepless sequence. One of the stops is furnished with a fine adjustment attachment for the grinding of blind holes. The machine can be operated either as a dry or as a wet grinder, in which latter case the cooling medium is circulated by a centrifugal pump. Two patterns of face grinding attachments are available and also a variety of work fixtures and clamping devices which are exhibited on the stand.

The Gear Grinding Company, Ltd.

On one of the stands taken by A. C. Wickman, Ltd., of Coventry, there are to be seen a number of gear-grinding machines made by the Gear Grinding Company, Ltd., of Handsworth, Birmingham. About two years ago, in a series of articles devoted to "Precision Grinding Machines," we described fully and illustrated several of the productions of this firm. The process adopted, it will be remembered, is one of form grinding. The wheel-dressing attachment is operated by a pantograph mechanism from a former made as a large-scale reproduction of the tooth form. Recently the firm has brought out a new machine, illustrated in Fig. 24, for grinding large batches of small gears or stem pinions, where high output is essential. Its general design is very similar to that of the spline-shaft grinder made by the same firm. Grinding nine planet pinions at each set up each with nineteen teeth 1·75 mm. Mod. 20 deg. pressure angle, it is stated that an output of thirty gears an hour, or 250 per 8½-hour day can be attained. A separate wheel truing device is used for each set-up, and the change over from one job to another is readily and rapidly effected by changing the truing device and the index plate. As each truing device is immediately ready for use and needs no adjustment, the machine can, it is said, be changed over from one job to another in about half an hour. As to the lasting accuracy of the truing device, we are informed that over 10,000 gears have been ground to an error not exceeding 0·0002in. without adjusting the diamond! The machine is hydraulically operated. Gears, mounted on mandrels, or stem pinions are held between centres in the manner shown in the illustration. The table is reciprocated under the wheel and after each double stroke, forward and return, the work is indexed one tooth. Operation is automatic. Cut is applied by raising an auxiliary table on an incline with a taper of 1 in 32, so that a fine feed can be obtained. The table is raised to a positive stop at which point the correct tooth depth has been reached. The vertical position of the wheel remains unaltered throughout, except when the truing device is brought into action. Since the truing device is permanently set at the correct level, trimming of the wheel does not require resetting of the work or any adjustment whatever. The travel of the table is adjusted by means of dogs, but for truing purposes the table can be traversed back without altering the position of these dogs.

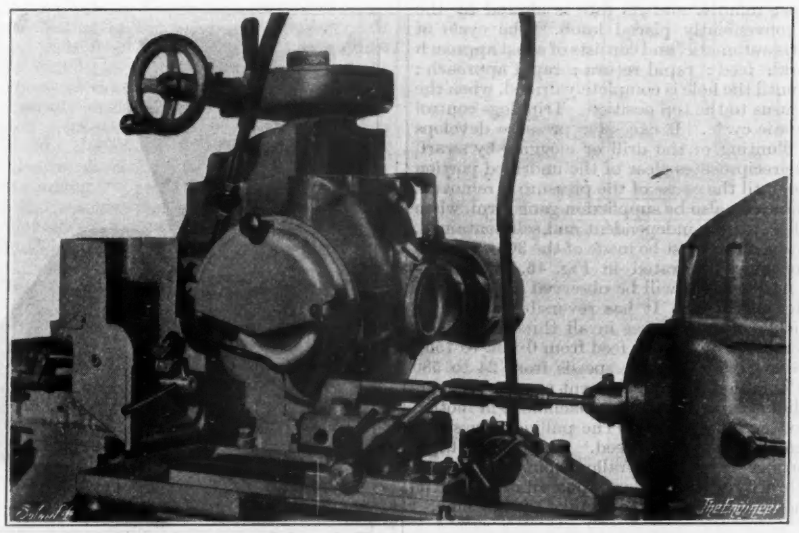


FIG. 24—SMALL GEAR GRINDER—GEAR GRINDING

Standard productions of the firm similar to those which we described in the series we mentioned at the beginning of this article, are to be seen on the stand, and also the involute measuring machine which we described in our issue of April 21st, 1933.

Wanderer-Werke A.G.

On the stand of Dowding and Doll, Ltd., there are exhibited a range of milling machines designed and built by Wanderer-Werke A.G., of Schönau-Chemnitz. For more than a generation this firm has specialised in milling machines, and has evolved a type the characteristic features of which are discernable alike in plain, vertical, and universal machines. The pyramidal column—see Fig. 26—encloses the driving motor and the box section over arm gives strength and stiffness with a pleasing outline and form. Other leading features of the design include a single-pulley drive, either for motor or main shaft, with laminated clutch or hydraulic control for starting and stopping.

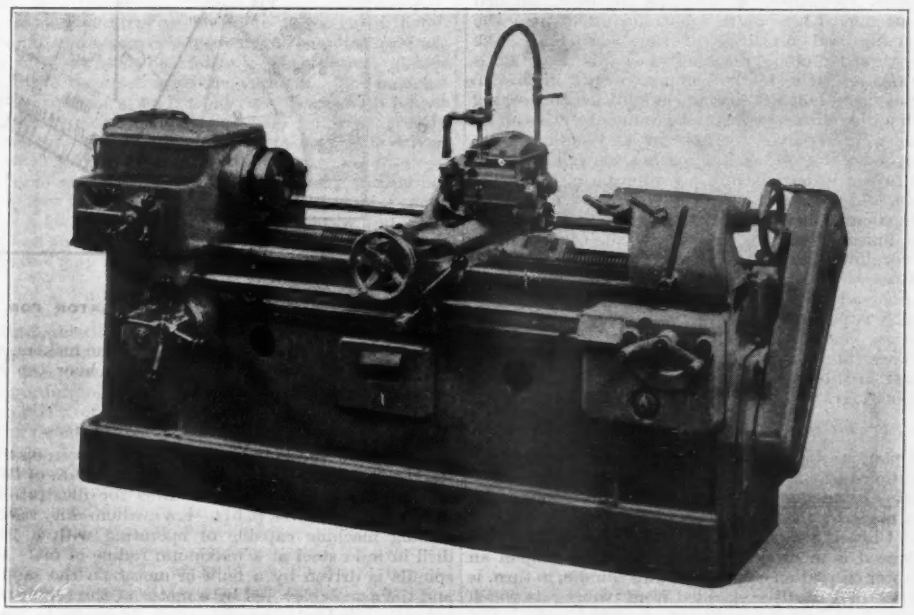


FIG. 25—LONG-THREAD MILLING MACHINE—WANDERER

A wide range of alternative machining speeds is provided, with feeds varying from heavy roughing cuts up to fine finishing feeds. All milling spindles are carried in ball bearings, and tapered roller bearings are employed for gear shafts. The gears, which are ground, are mounted on splined shafts in cases where a sliding motion is required. The particular example we have chosen for illustration—see Fig. 26—is the new hydro-automatic, high-production, milling machine, No. 52 P H, which has hydraulic drive and control for the table traverse motion. The spindle drive is mechanical, but the stopping and starting of the spindle is controlled hydraulically. The hydraulic table drive gives a stepless feed variation from zero up to 40in. per minute, and two rates of quick-power traverse, namely, 80in. and 160in. per minute in both directions. When the table traverse is arrested, or when the quick-power traverse is engaged, the spindle head is hydraulically unclamped from the column and raised to clear the work. When it is desired to engage the feed, the milling head is again automatically lowered vertically to the predetermined point, and is then clamped to

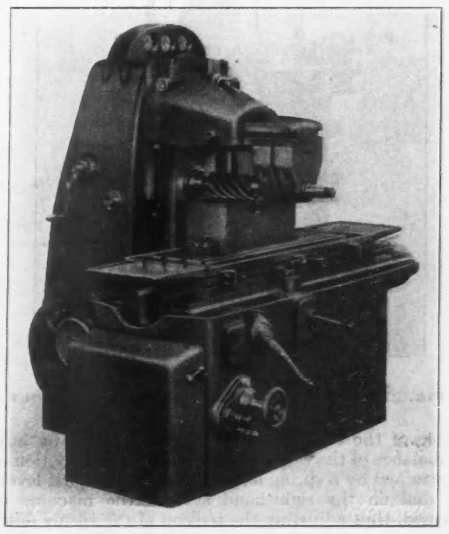


FIG. 26—MILLING MACHINE—WANDERER

the column. These automatic movements operate irrespective of the table being governed by pre-adjustable trip dogs.

The Wanderer-Werke firm has also devoted considerable attention to new developments in thread milling, and some representative types of automatic short-thread milling machines and a universal long-thread milling machine are shown on the stand. A point of interest in the case of the short-thread machine, which we do not illustrate, is the fact that the lead of the thread to be milled is governed by a face cam of very large diameter. In comparison with the usual screw and nut, or leader and follower, employed on some other machines, considerable time is saved on the return of the work head spindle into the starting position by a step on the face of the cam corresponding to the completion of a thread, which causes a very rapid return of the spindle to the starting position. The face cam has also the additional advantage that it can be used for right or left-hand threads. Automatic control mechanism is applied to all movements of the machine other than the clamping and replacing of the workpiece. The long-thread milling machine shown in Fig. 25 is claimed to show marked improvements in design. It has been designed so that, in addition to working with a disc cutter, or annular group cutter, it can be quite well employed for hobbing and similar work. A cylindrical group cutter reaches the full depth of the thread in one-sixth of a revolution of the workpiece, and finishes the thread as the work makes the next complete revolution. The whole of the cutting and finishing operation is, therefore, completed in $1\frac{1}{6}$ revolutions, which, with short threads especially, enables very high production rates to be maintained. The thread milling machines are built in such a way that it is possible to adapt them quickly as special-purpose machines. The firm is also showing a representative range of work jigs and fixtures which have been evolved for use with its specialised productions.

THE GISHOLT MACHINE COMPANY, LTD.

Upon one of the stands taken by Burton, Griffiths and Co., Ltd., of Birmingham, there is to be seen the static balancing machine illustrated in Fig. 27, and made by the Gisholt Machine Company, Ltd., of the United States. In operation the part to be balanced is mounted with its axis vertical upon an adapter carried on a spindle. This spindle, in turn, is carried in a cradle suspended from two pivots which allow the adapter to rock in one plane only. The

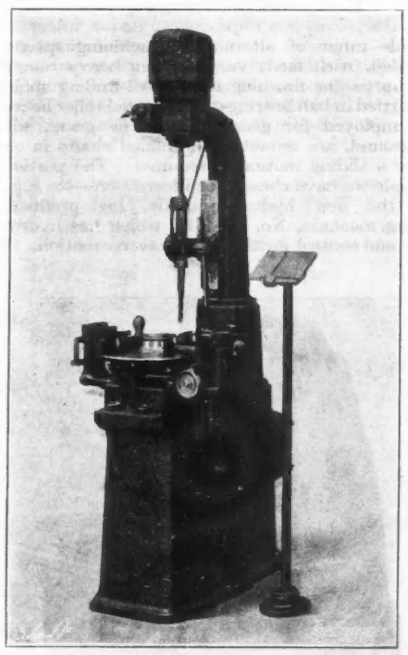


FIG. 27—STATIC BALANCING MACHINE—GISHOLT

table of the cradle can be rotated. Naturally any unbalance of the work tilts the cradle. This motion is restrained by a spring and indicated by a spirit level. A dial on the right-hand side of the machine is turned, thus adjusting the tension of the spring until the cradle is brought back to the level position. The reading on the dial is noted and, for rapid calculation when the process of balancing has been completed, the vertical scale G on the calculator illustrated in Fig. 28, is set on scale H to this reading. Next the part being balanced is turned through 90 deg. by swinging the table of the cradle which is suitably graduated, and the level again restored by operation of the dial. This time the reading is transferred to the calculator by setting the scale K to intersect the vertical scale G at the reading concerned. Reference is next made to the protractor scale M, the pointer upon which indicates four possible readings. A choice is made according to whether the dial of the machine was turned on both occasions in the plusly or in the minusly direction or in a plusly and a minusly, or a minusly and a plusly direction. A small indicator above the protractor is provided to assist the memory. The reading having been determined the table of the machine, together with the work, is turned into the angular position indicated on the protractor and locked. The drill spindle is then brought into use. The calculator scale is calibrated for use with a $\frac{7}{16}$ in. drill operating at a radius of $6\frac{3}{8}$in. and the reading upon the scale K indicates the number of holes to be drilled and their depth. According to the makers, as many pieces as thirty-five to forty per hour can be balanced and corrected.

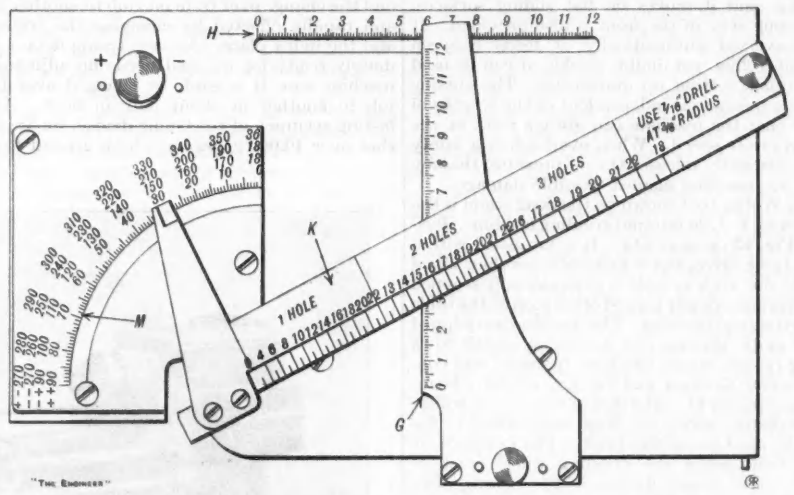


FIG. 28—CALCULATOR FOR GISHOLT BALANCING MACHINE

JAMES ARCHDALE AND CO., LTD.

There are several interesting tools to be seen on the stand taken by James Archdale and Co., Ltd., of Birmingham. We have chosen three for illustration. The first—see Fig. 44, p. 514—is a medium-duty radial drilling machine capable of operating with a 2in. drill in mild steel at a maximum radius of 5ft. Its spindle is driven by a built-in motor on the saddle and the arm is elevated by a motor at the top of the column. Eighteen spindle speeds from 50 to 2000 r.p.m. are available, and there is little chance of a wrong choice being made. The correct speed is selected by setting a pointer against the material to be drilled and turning an indicator drum to the size of hole required. A single lever controlling a servo-operated multi-plate clutch stops, starts, and reverses the motion of the spindle. Six feeds from 30 to 240 r.p.i. are obtainable, and for the protection of the mechanism there are safety slipping clutches in the drive. The fine hand feed wheel remains stationary when the automatic feed is engaged. Every control for the machine is conveniently arranged upon the saddle. The arm, for instance, is unlocked, elevated or lowered and locked again by the use of two buttons. The arm swings on roller bearings.

In the second illustration, Fig. 45, there is to be seen a deep hole drilling machine, capable of drilling holes $\frac{3}{4}$in. diameter to a depth of 8in. It is fitted with an hydraulic relieving feed and is driven by a single constant-speed vertical motor mounted on the head. The hydraulic feed is infinitely variable between 0 and 6in. per minute, and its rate is altered by the use of a conveniently placed knob. The cycle of operations is automatic, and consists of a fast approach to the work; feed; rapid return; rapid approach; feed, &c., until the hole is completely drilled, when the spindle returns to the top position. Trip dogs control the automatic cycle. If excessive pressure develops owing to blunting of the drill or clogging by swarf, the spindle reciprocates clear of the undrilled portion of the hole until the cause of the pressure is removed. This machine can also be supplied in gang form, when each head is entirely independent and self-contained.

Thirdly, mention must be made of the 30in. vertical milling machine illustrated in Fig. 46. Its strong and rigid construction will be observed by examination of the engraving. It has reversible automatic feeds, quick power traverses in all three directions, and eight rates of automatic feed from 0·7in. to 15in. per minute. Sixteen spindle speeds from 24 to 580 r.p.m. are obtained through a patent preselector gearbox. A dial is turned while the machine is in motion to the next speed required. The pulling of a single lever then engages this speed. Adjustable taper roller bearings carry a Nitralloy spindle which is fitted with a fly-wheel to damp out vibration. The driving motor is housed in the body of the machine.

CARTER AND WRIGHT (ENGINEERS AND MACHINE TOOLS), LTD.

A handy little sawing machine for general purposes on the fitting bench, which is shown by Carter and Wright (Engineers and Machine Tools), Ltd., of Pellon-lane, Halifax, is illustrated in Fig. 29. A circular saw is used, of either $4\frac{1}{2}$in. or $7\frac{1}{2}$in. diameter, and is mounted on a spindle in a horizontal slide. It is driven through gearing by a small electric motor. Alongside the slide there is a table on which the work can be bolted, or it may be held in the vice shown if convenient. At the front end of the slide, it will be seen, there is a handle, which, when turned to the right, puts the driving gear into operation and the saw quickly moves up to the work; but when the saw starts cutting, the feed automatically adjusts itself to the resistance. When the cut has been made the handle is turned back to the left to stop the feed, and the saw is pulled back by hand. There is an automatic stop to the feed when the slide has run the full length of its travel. The machine will cut, say, a 1in. square steel bar in 60 seconds.

The chip-crushing machine shown in Fig. 30

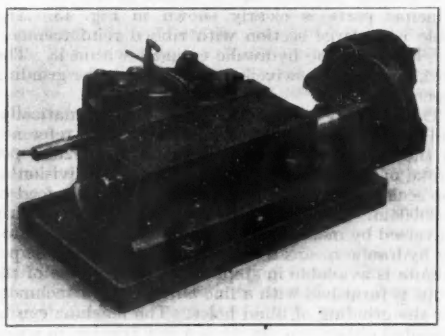


FIG. 29—BENCH SAW—CARTER AND WRIGHT

is intended for mashing up long and curly steel turnings so that they may be packed more tightly and be easily handled with a shovel. Inside the hopper there is a vertical rotating shaft fitted with knives which work in conjunction with other spiral knives fixed in the hopper. As the shaft revolves the chips are drawn down to a further set of knives, which crush them to the desired size, when they slide down the discharge outlet into any convenient

FIG. 30—CHIP CRUSHER—CARTER AND WRIGHT

receptacle. A chip clearer revolves in the discharge outlet to prevent jamming. There is a shearing pin in the drive, which breaks if any massive piece of metal should get in between the knives, and doors are arranged in the sides of the hopper, which is of cast steel, to facilitate clearing away obstructions. One of these machines, capable of dealing with a ton

of swarf in an eight-hour day, requires about 3 horse-power.

Another machine on this stand is a keyseater capable of cutting keyways up to ¾in. wide by 12in. long. The work piece is fixed on a table measuring 20in. by 6½in., and the end milling cutter is traversed on a slide above it. The spindle is driven by phosphor bronze spiral gears, and is traversed by a screw, which is driven by reversing mitre gears. Two changes of speed are provided for the traverse. The feed of the mill into the work is operated automatically by ratchet gearing, and can take place at any position along the length of the traverse.

The Timbrell and Wright Machine Tool and Engineering Company, Ltd.

The small machine illustrated in Fig. 31 has been developed by the Timbrell and Wright Machine Tool and Engineering Company, Ltd., of Birmingham, to meet the demand for a simple and plain automatic which will do much of the work now being done on capstan lathes and more elaborate automatic machines. Its design is simple and it is capable of doing work within its capacity in either brass or steel. The headstock spindle is hardened and ground, and runs in ball and roller bearings, and the nose-cap for the collets is also case hardened and is ground in position to ensure its truth. The tube for closing the collet for gripping the stock is fitted with a hardened pressure piece to take the thrust of the toggle levers, and the tube for feeding the stock to the stop has a hardened chuck fitted to grip the stock. Two open-side tool posts, the front one of which has adjustment in line with and at right angles to the spindle, are fitted to the forming and cutting-off slide.

The tailstock has a floating spindle which carries two tools and the stop for length. Each tool is brought into action at the correct time by the rotation of the spindle through gear wheels. The spindle

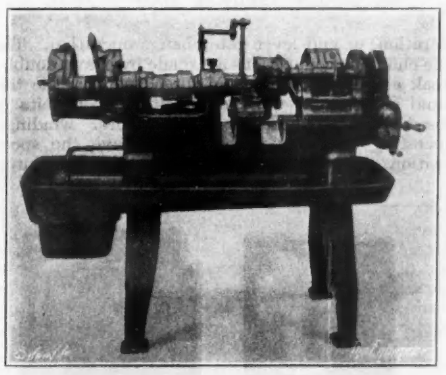


Fig. 31—Small Automatic—Timbrell & Wright

is fed forward to the work by cams bolted on the drum on the back shaft, and the hardened plunger which locates the tools engages with hardened bushes in the barrel, and is withdrawn on the backward stroke of the spindle. The spindle is hardened and ground and has phosphor bronze bearings, which are renewable.

The shaft which carries the cam drum is placed at the back of the machine. It is carried in arms which are cast solid with the bed, and the bearings are bored at the same setting as the head and tailstocks. It is driven by belt from the countershaft through a pair of fast and loose pulleys provided with a belt shifter. The steel worm and phosphor bronze worm wheel are totally enclosed and run in oil, and six steel pick-off gear wheels are supplied to give five rates of feed to the shaft. A hand-control lever is fitted to the worm shaft and is disengaged when machine is running.

Besides the machine just described the firm is showing high-speed capstan lathes and a circular sawing-off machine.

George Richards and Co., Ltd.

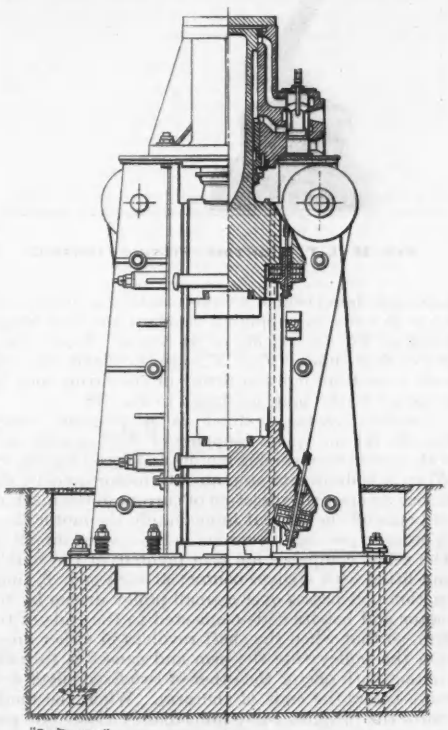
The universal surfacing, boring, milling, drilling, and tapping machine, similar to that illustrated in Fig. 47, page 514, which is exhibited at Olympia by George Richards and Co., Ltd., of Broadheath, Manchester, is fitted with the Murray colour control system, which it is believed will greatly simplify the selection of speeds and feeds. Instead of the usual plate bearing a table of speeds, according to the setting of the control levers, there is a disc face cut with slots behind which another disc can be rotated. The latter is turned until in one of the slots there appears a figure corresponding to the desired speed. Supposing that there are three levers concerned in speed changing, it will now be found that certain "devices" have appeared in three other slots in the face disc which are placed relatively to one another in a disposition similar to that of the levers concerned. The "devices" may be of several different colours and shaped as triangles, squares, circles, hearts, &c. Each of the positions that each operating lever can take up are similarly marked with a coloured "device." In order to obtain the speed appearing on the face of the disc, it is only necessary to place the levers in those positions, the "devices" of which correspond with those appearing on the disc. With the object of simplifying matters still further, other levers, such as the stop and start, power traverse, &c., bear upon the knobs at their ends distinguishing marks. That for the stop and start lever, for instance, is a pair of railway signals, one "on" and the other "off."

The machine itself has a traversing spindle 5in. in diameter and a facing capacity up to 54in. diameter. The spindle and facing head can be revolved either independently or simultaneously. Speeds ranging from 1·3 to 162 r.p.m. are available for the traversing spindle and the facing head has thirty speeds from 1·3 to 116 r.p.m. Eight automatic feeds are given to the facing slide, ranging from 0·019in. to 0·258in., and a similar number from 0·009in. to 0·129in. are provided for traversing the spindle horizontally, the spindle frame vertically, and the tables longitudinally and transversely. Rules and verniers are fitted to the vertical, longitudinal, and transverse movements, enabling accurate adjustments to be made. Magnifying glasses facilitate the reading of the verniers. The machine has an upright of an entirely new design with patent prismatic slides, which are said to give greatly increased support to the spindle frame. It is driven through texropes by a 25 H.P. motor.

There are a number of other surfacing and boring machines to be seen on the stand, and among other tools a 5ft. double standard vertical boring and turning mill and a vertical slot drilling and keyway-cutting machine may be mentioned.

Beche und Grohs G.m.b.H.

Undoubtedly one of the most interesting of the larger exhibits of working machinery at Olympia is the 32in. stroke, 29,000 foot-pounds blow, double-swage, forging hammer, made by Bêché und Grohs G.m.b.H., of Huckeswagen, Rheinland, which is being demonstrated on one of the Empire Hall stands of Leo. C. Steinle, Ltd., of 81, Marsham-street, Westminster, London. The example shown is one of a range of thirteen hammers, with a range of tup strokes from 16in. up to 48in., and with designed effective blows of 3625 foot-pounds up to 181,000 foot-pounds. The general construction of the hammer is shown in Fig. 32, while in Fig. 33 we reproduce a view of a typical factory installation. The distinguishing feature of the design is the use of two similar tups which strike against each other at the same speed and thus do away with the necessity for anvil blocks and heavy foundations. The left-hand view



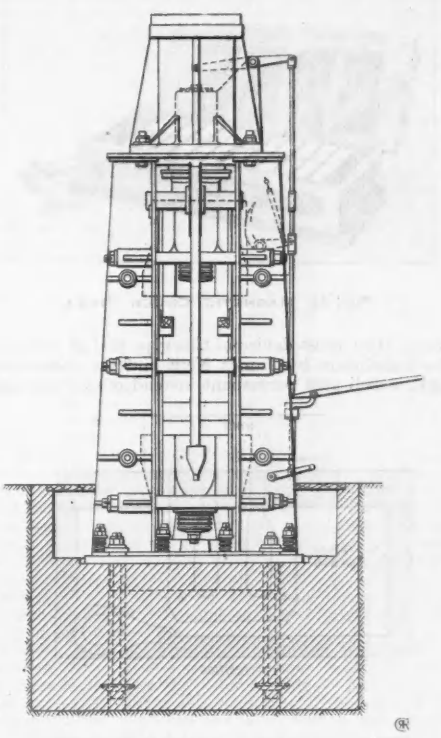


Fig. 32—Double Tup Hammer—Beche

in Fig. 32 shows the air control valve and the air ports leading to the upper ram cylinder. By means of projections on the back of the rams or tups they are interconnected by driving bands consisting of a number of interleaved flexible steel strips, with a neat arrangement of rubber buffer discs at either end to minimise shock and to equalise the load on the various steel bands. The main framing of the hammer is built up from welded plate about 1in. in thickness, and the side frames are clamped together by through bolts. The cast iron air cylinder is mounted on the top frame plate and the guide pulleys for the steel bands are positioned just below the cylinder in the manner illustrated in Fig. 32.

At the Exhibition the flexibility of the hammer for forging work is demonstrated. The following figures relate to a 33 lb. crank shaft for a 1-litre petrol engine, forged with a 29,000 lb. hammer. The shaft is made in two bending blows and about six swage blows at one heating, and the average output is 250 to 300 shafts in eight hours. When worked with

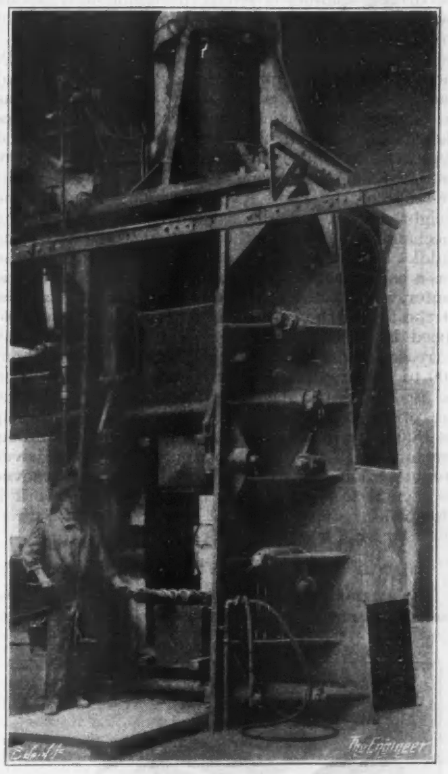


Fig. 33—Double Tup Hammer—Beche

ordinary compressed air at about 100 lb. per square inch about 60 H.P. is required, but when the air is heated this power falls to about 40 H.P.

The hammer can also be very conveniently employed for the preliminary process of rolling before forging, in which the work is held and turned by the tongs. The central tup position and the falling lower tup enable the work to be easily turned when using short rapid blows.

Adcock and Shipley, Ltd.

The machines on the stand of Adcock and Shipley, Ltd., Bright-street, Leicester, are of a comparatively light nature, such as high-speed sensitive drills, small milling machines, and so forth, but some of them are of a quite special nature. One is a horizontal drilling machine specially devised for a piston manufacturer, who has both long and short runs on various types of pistons for motor engines. It is used to drill the oil drain holes and readily lends

itself to any particular requirements where the holes have to be drilled radially. The piston is clamped in a vertical position by a jig fixture, which fits the skirt of the piston and the gudgeon pin holes. The work table, with this fixture, is rotated to give the spacing of the holes drilled, and the spacing can be varied by changing the driving plates. One of the drilling spindles is driven through a shaft having two universal joints, so that the distance apart of the two holes, which are drilled simultaneously, can be varied. The machine is driven by a 1 H.P. motor running at approximately 1500 r.p.m., and has an output of about seventy aluminium pistons an hour. The vertical sensitive drilling machines shown are of both the hand and automatic feed type. In the latter case three changes of feed are provided, and are brought into action by a slight pressure of the hand lever through its axis. The weight of the spindle is balanced by a spring mechanism carried in the hood at the top of the saddle. The spindle runs in ball bearings, and also has a ball thrust washer. In another type the electric motor, for two and three-phase supply only, is carried at the top of the column, and gives four changes of speed by electrical means. A two-speed gear-box increases the range to eight speeds of from about 100 to 1455 r.p.m. A conveniently placed lever can be used to reverse the motor for tapping jobs. There are other drilling machines for speeds ranging up to 18,000 r.p.m., and some handy little plain milling machines. In these the horizontal spindle is driven from the motor through a V-belt, which can be moved to several steps of a cone pulley, and the work is clamped on a slide rest that is operated in all directions by hand levers and links.

James Neill and Co. (Sheffield), Ltd.

The magnetic chuck is a device of proved usefulness and can be used for holding quite a large variety of

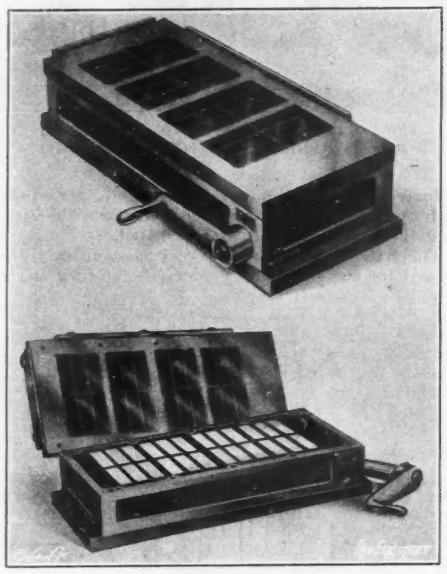


FIG. 34—MAGNETIC CHUCK—NEILL

work. The latest device of this type is that shown at the Exhibition by James Neill and Co. (Sheffield), Ltd., which uses permanent instead of electric mag-

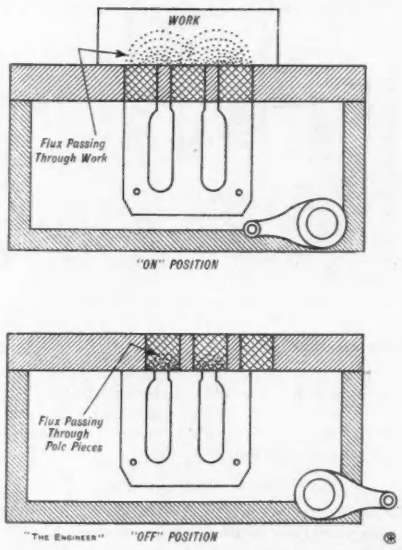


FIG. 35—DIAGRAM SHOWING OPERATION OF CHUCK

nets. Lest it might be thought that the permanent magnets might lose their power, it is worth repeating the manufacturer's statement that this chuck can only become demagnetised by contact with a severe demagnetising force. Should any such accident occur, the chuck can be re-magnetised, for which service the manufacturers are willing to make no charge other than carriage to or from their works. The device is illustrated in the two engravings, Figs. 34 and 35. The magnet unit consists of eight three-pole permanent magnets mounted on a slide movable by means of an external handle. Above the magnets there is a top plate constructed of a nickel-iron non-magnetic alloy, with high permeability steel inserts. The base plate is made of the same alloy and the main body, for lightness, is an aluminium alloy die casting. The ingenious method of turning the magnet force "on" and "off" is illustrated by the line engraving, Fig. 35. When the magnet poles are located directly beneath the high permeability steel pole pieces, they induce in them a high flux density, and there is a large magnetic flux available on their upper surfaces, to which objects of iron and steel will adhere strongly. When, by the use of the handle, the magnets are slid sideways, the steel pole pieces act virtually as "keepers," and there is practically no external flux on their upper surfaces, so that work pieces can easily be removed and the chuck readily cleaned for further work. The joint between the top plate and the housing is sealed to prevent the entry of coolant when the chuck is used for wet grinding.

Igranic Electric Company.

Among the many interesting electrical exhibits of the Igranic Electric Company, of 147, Queen Victoria-street, E.C.4, are low-voltage lighting equipments for use in connection with machine tools, on which a low-pressure is desirable in the interests of safety. A transformer switch unit for use with a separate lighting fitting consists of a step-down transformer, double-pole, push-button switch, and double pole fuse unit, all enclosed in a neat metal case, as shown in Fig. 37. Transformers are supplied for connection to lighting or power circuits operating at 200–250 volts or 400–440 volts, and at frequencies of 50 to 60 cycles. The secondaries can be wound for a

FIG. 36—L.T. LIGHTING FITTING—IGRANIC

maximum lamp load of 48 watts and for a pressure of 12 or 25 volts for supplying standard gas-filled lamps rated at 12, 18, 24, 36, or 48 watts. Transformer switch-fuse units, Fig. 37, are available for use with a separate lighting fitting or the fitting may be attached to the unit, as shown in Fig. 36.

Another Igranic exhibit is a plugging relay, Fig. 38, for the quick stopping of A.C. motors used with automatic reversing motors and speed regulators. When it is desired to stop an A.C. motor quickly, the device reverses the direction of current in the machine and cuts off the current immediately the motor stops in order to prevent it running in the reverse direction. The relay comprises an arm pivoted in the middle and fitted with a silver contact at each end. A small friction belt passes over a small pulley driven by the motor and has its ends connected to the ends of the arm, so that when the shaft revolves in either direction the pulley tilts the arm and causes it to make contact with one or the other of two fixed silver contacts below the ends of the arm. When the motor starts the plugging relay immediately closes one pair of contacts which remains closed as long as the machine is running. When the "stop" button on the master switch is depressed, however, the main line contactor opens and disconnects the motor from the line. Interlocks on the contactor then close the circuit to the coil of the reversing contactor, through the contact in the plugging relay and reverse power is supplied to the motor. As soon as the motor stops and just begins to reverse, the pulley and friction belt open the plugging relay contact, thereby opening the circuit to the coil of the reversing contactor, which opens and disconnects the motor from the line. For speeds from 50–1800 r.p.m. the relay can be connected directly to the motor shaft, through a flexible coupling whilst for higher speeds a chain drive arrangement or other form of speed reducer may be used to reduce the speed of the relay pulley.

The controller shown in Fig. 39 is one of several shown for use with change-pole squirrel-cage motors, which are being widely used for driving drilling and tapping machines. The controllers are made for two, three, and four-speed, squirrel-cage machines up to 3 horse-power at 200 to 500 volts. The controllers are being exhibited in conjunction with a B.T.H. motor designed for four speeds. They are supplied for central lever (ball change) operation, push-button

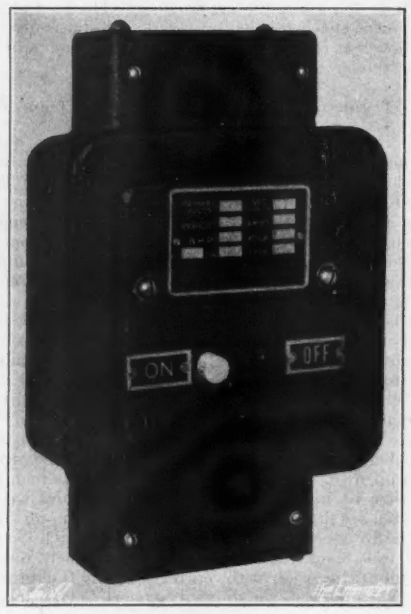


FIG. 37—L.T. LIGHTING UNIT—IGRANIC

operation, or end lever gate change operation. The pole-changing connections are made by heavy double-break contacts composed of forged copper, the terminal board being marked for either open delta or closed delta connection of the motor windings. Operating levers or push buttons have the speed positions clearly indicated and mechanical inter-

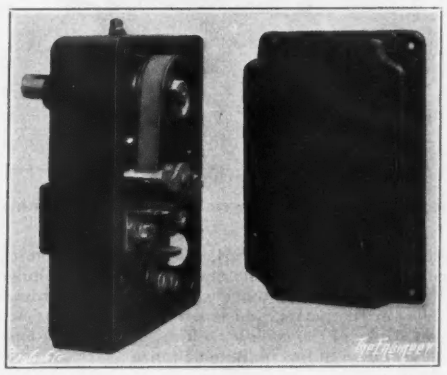


FIG. 38—PLUGGING RELAY—IGRANIC

locks ensure correct operation. Motors operating on 25-cycle circuits can be made to run with the aid of these controllers at two or three speeds, and those operating at 50 or 60 cycles at two, three, or four speeds. A reversing switch may be incorporated in two-speed controllers or in a separate enclosure for three and four-speed controllers. When no-volt

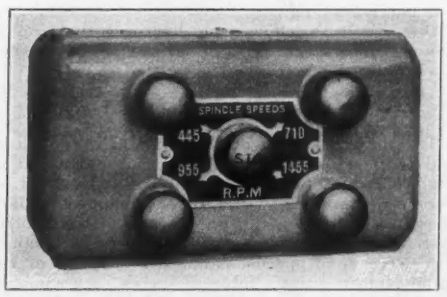


FIG. 39—MOTOR CONTROLLER—IGRANIC

release and overload protection are desired, the controllers are used in conjunction with a contactor when the maximum capacity is increased to 5 horse-power at 230 volts or 7½ horse-power at 400–550 volts.

The electronic automatic timing controller shown in Fig. 40, for use with spot welders, is claimed to give precise timing and to ensure perfect welds. It eliminates waste resulting from weak or burned welds and reduces inspection and testing costs. The controller consists of a combination of a thermionic

valve with condensers and an adjustable rheostat, together with a transformer and control relay. The act of bringing the electrodes together on the material to be welded closes a control switch on the spot welder thus actuating a control relay and causing the separate main contactor to close and pass current through the electrodes, when the thermionic valve and condenser determine the period of the weld according to the setting of the adjustable rheostat. The control relay contacts open at a predetermined fraction of a second and consequently the main contactor opens to terminate the weld, when the apparatus is ready for the next operation. By moving the knob of the adjustable rheostat the duration of the weld can be varied by virtually imperceptable amounts from one-tenth of a second up to a maximum of three seconds, and when once set the controller auto-

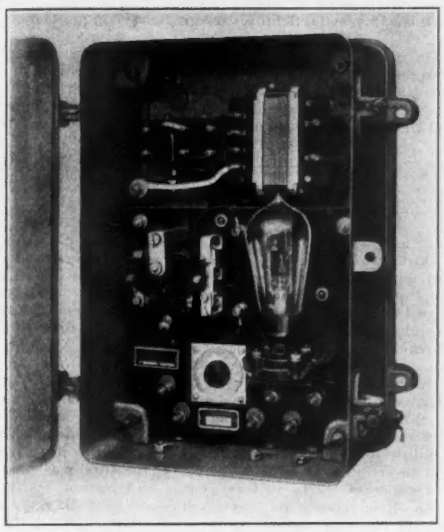


FIG. 40—SPOT WELDER TIMER—IGRANIC

matically repeats the correct welding time even if the period is only a small fraction of a second. All the operator has to do is to feed the machine and to bring the electrodes together to initiate the weld, the critical operation of timing being entirely automatic. The controller can be supplied with the timing adjusting device protruding through the case, or, alternatively, it may be entirely enclosed in the case, when the door must be opened to make the adjustment. The system can be used on circuits working at all standard voltages and all frequencies between 25 and 60 cycles. Existing spot welders are easily converted to work with this automatic timing system, but when applying the controller to very large welders it is desirable to feed the apparatus from a separate circuit, which is not subjected to the voltage fluctuations caused by the heavy rush of current.

THE MOSS GEAR COMPANY, LTD.

Examples of single helical, double helical, worm, and planetery gearing are exhibited by the Moss Gear Company, Ltd., of Tyburn, Birmingham. It is difficult to make an interesting description of the various units to be seen on the stand, and we can do no more than mention one or two which will give some idea of the range produced. There is, for instance, a triple reduction gearing unit capable of transmitting 10 H.P. at a 750 to 1 ratio, the final speed being 1 r.p.m. The high-speed gears are double helical, hardened, and lapped, and the second and third reductions are through "Moss" full encircling worm gears. Another exhibit is a 125 H.P. 8in. centres totally enclosed double helical speed increasing gear, having a 5 to 1 ratio at 1500/2500 r.p.m. It is fitted with an oil cooler and pressure lubrication to the bearings and sprayers.

Perhaps the most interesting device shown is the fan-cooled worm gear unit, sections through which are reproduced in Fig. 41. It is made in a range of sizes for various speeds and powers. A continuous stream of air is directed along the cooling fins cast on each side of and beneath the gear casing by means of an aluminium fan mounted on an extension of the high-speed shaft; and this efficient cooling allows high powers to be transmitted by a compact unit. Deflectors are arranged to give a further supply of air by induction. The worm is made of alloy steel of high nickel content, combining high torsional core strength with a glass hard surface. The worm wheel centre is of cast iron on to which there is shrunk and pegged a phosphor bronze rim. The rim is centrifugally cast, and its teeth are hobbed by a generating process. Ball and roller bearings are used throughout. Oil flingers on the worm shaft throw a large quantity of oil on to the wheel as it enters into mesh, and also produce an oil mist which penetrates to the ball bearings. Oil is drained back to the sump through large passages. The manufacturers advise that the gear unit and driving motor should be mounted on a substantial combined bed plate, and that whenever possible they should be connected by a flexible coupling to give axial freedom on the high-speed shaft.

(To be continued.)

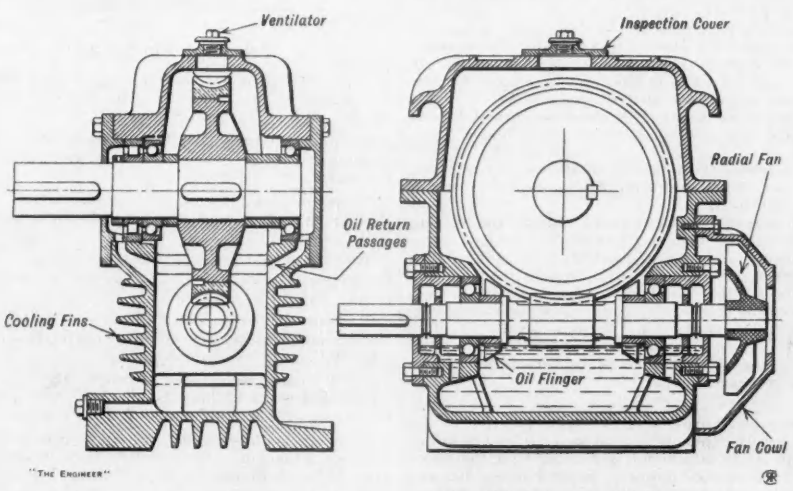


FIG. 41—FAN-COOLED WORM GEAR UNIT

Robert Fulton's Original Drawings.

By FREDERICK D. HERBERT.*

A VALUABLE set of Robert Fulton's patent drawings was discovered in London when the offices of THE ENGINEER were being moved to a new location.† These drawings were brought by the writer to this country as a gift from THE ENGINEER to the American Society of Mechanical Engineers. After cleaning and mounting, they were shown to several members of our Society and, because of their great historical value, it is deemed wise to place them in the form of a permanent record in the "Transactions" of our Society; therefore, the most important sixteen of the set of twenty drawings are reproduced in this paper. The originals are tinted drawings 30in. by 20in.

In a letter announcing the discovery of the drawings and offering them to the American Society of Mechanical Engineers, Mr. Loughnan St. L. Pendred, editor of THE ENGINEER, stated that he had submitted the drawings to Mr. H. W. Dickinson, keeper of the Science Museum, South Kensington, and Honorary Secretary of the Newcomen Society for the Study of Engineering and Technology.

Mr. Dickinson at once advised him that the collection was a wonderfully and wholly unexpected find. The drawings are, in fact, duplicates of those made by Fulton on his patent specifications. The following memorandum was prepared by Mr. Dickinson, who is the author of "Robert Fulton: Engineer and Artist," published in London in 1912. A complete set of small-size reproductions of these Fulton drawings appeared in that book, in which also are given the full U.S. patents.

MR. DICKINSON'S MEMORANDUM.

These drawings were found with other papers in the offices of THE ENGINEER when removing from 33, Norfolk-street to the new premises. How long they had been in the office or where they came from is not recorded, but an explanation is suggested below. They bear no marks of identity except the name of the draughtsman, "J. Kearney"; the watermark is "J. Whatman 1794" and "T. G. & Co."

On examination they turn out to be the drawings of Robert Fulton's United States patent specifications of 1809, February 11th, and 1810, October 2nd, for his steamboat. Furthermore, these drawings are with little doubt those which Fulton entrusted in 1811 to Joseph C. Dyer (1780–1871), a compatriot favourably known in England as an inventor, for the purpose of promoting the adoption of the steamboat in England.

Mr. Dyer says: "I undertook, in 1811, the task of inducing some of the leading engineers and capitalists of London to engage in the introduction of steamboats, on Fulton's plan, to run on the Thames and other waters of this country. Believing that they must soon be adopted and become of great importance to England, I had obtained from Mr. Fulton (through a mutual friend) a full description and drawings of his inventions and discoveries relating to steam navigation, with the result of his labours in America. But I found it impossible to convince any of them that steamboats could be made to run with safety and profit in the English waters. The general reply was, 'We don't doubt the success of steamboats in the large American rivers and inlets from the sea, but they will never answer in our (comparatively) small rivers and crowded harbours.'"

Dyer goes on to say that he was dissuaded by personal friends and distinguished engineers from wasting his "time and money on so hopeless a task as that of introducing steam navigation into England." Mr. Peter Ewart, a well-known engineer and personal friend of Dyer, who had been employed by Boulton and Watt on the erection of Soho Foundry, in 1814 borrowed the drawings "which were sent by him to Boulton and Watt and returned to me about six months after. I have reason to believe that eminent house was led thereby to make further and more exact inquiries concerning the progress of steam navigation in America, for they, as well as several other engineers, commenced building steamboats in 1815 and 1816."

In the Boulton and Watt collection at the Birmingham (England) Reference Library there are to-day copies of the drawings and also of the specifications; that these can only have been taken from Dyer's papers is evidenced by the fact that there is a hiatus in both sets, *i.e.*, "Drawing 12th," specification of 1809, and "Drawing 6th," specification of 1810, are missing. Furthermore, in the Patent Office Library there is another copy of a specification with tracings of the drawings, and in these again the same hiatus occurs; the latter documents appear to be those obtained from Mr. Dyer by Mr. Bennett Woodcroft, F.R.S., when he was preparing his work on "The Origin and Progress of Steam Navigation," 1848. Woodcroft subsequently became Clerk to the Commissioners of Patents, and the documents in question are in the Woodcroft collection that he left to the Library.

The present set of documents may be looked upon as authorised copies of the originals filed in the U.S. Patent Office, and this gives them a peculiar value because the originals are no longer in existence, as they perished in the disastrous fire that took place in the U.S. Patent Office in 1836, which consumed so much of value for the industrial history of the United States.

BIOGRAPHICAL SKETCH.

It is well here to turn to some of the outstanding events in the life of Robert Fulton bearing on the character and genius behind the development of these remarkable drawings.

At the age of twenty-one, Robert Fulton sailed from Philadelphia with a letter of introduction from Benjamin Franklin to Benjamin West, of London, the eminent American portrait painter, for the purpose of continuing work in his chosen profession. West took him into his house, gave him instructions and introduced him to his friends. Several portraits and miniatures now in existence speak of the high ability of young Fulton, including the one of himself which hangs in the rooms of the American Society of Mechanical Engineers.

A few years later he became interested in the extensive system of canals then building throughout England, and gave up painting. However, this talent served him well during the rest of his career to illustrate by sketches and drawings the many mechanical ideas that he developed and promoted. Copies of his voluminous correspondence describe a paddle wheel steamboat as early as 1793, a system of inclined planes for lifting and lowering canal boats, an excavating machine for digging canals, and a windmill for cutting marble. These letters are models in clarity of description, courtesy to his correspondent, and appeal for approval of his project that might well be followed by any promoting engineer.

In 1797 he went to France and there built a submarine and floating mines. Before a committee appointed by Napoleon Bonaparte he navigated his 20ft. "Nautilus," much of the time submerged and driven by a two-blade propeller on a shaft turned by hand, 70 miles along the English Channel.

Chancellor Robert R. Livingston met Fulton in Paris and at once the two formed a close friendship. Both were interested in the application of steam to navigation. They immediately built on the Seine a small paddle wheel boat with a steam cylinder 2in. by 24in. and a flash boiler of 32 atmospheres that was replaced by one of lower pressure. The boat ran successfully and the two men, in 1802, formed a partnership for building a 120ft. boat. Fulton's drawing is of a vertical double-acting engine driving paddle wheels much the same as those illustrated in this series of patent drawings.

Fulton mailed an order to Boulton and Watt, of Birmingham, for "a 24-horse-power double-effect engine, 24 inches in diameter, the piston making a 4-foot stroke," with valves, air pump and condenser, to be shipped to America. The order was declined because the British Government would not issue an export licence. Fulton then interested the Admiralty in his torpedoes and mines and received for his three years' experiments a fee of £10,000 and £5000 for expenses. The export licence was obtained, the order to Boulton and Watt was reinstated at a price of £380, and in seven months all was ready for shipment to New York.

One change in the contract is of particular interest; Fulton ordered the air pump to be of brass instead of iron and the extra cost was £148, or an increase of nearly 40 per cent. A copper boiler was also bought in England for £477.

Fulton arrived in New York in December, 1806, twenty years after he left, and devoted his great abilities to building the hull and machinery and installing the engine and boiler of his steamboat. The builders' trial took place the following August on the scheduled date and it was a success. The first trip to Albany on August 17th averaged nearly 5 miles an hour, 150 miles in 32 hours and 30 hours return. Two weeks later the "Steamboat" entered regular service between New York and Albany, making

* Am. Soc. of Mechanical Engineers.—Nov. 15th.

† May 16th, 1930.

three round trips every two weeks, and thus was inaugurated the first regular commercial steamboat.

Other boats followed quickly. The following year the "Steamboat" was rebuilt to larger dimensions and renamed the "Clermont," and two new vessels, the "Raritan" and the "Car of Neptune," were added to the fleet. Within nine years of his return to New York, Fulton built a total of eighteen steamboats, for the Hudson, Raritan, Potomac, and Mississippi rivers, for Long Island Sound and for harbour and ferry services. Each ship was an improvement over its predecessors, and remarkable cleverness and originality of design are shown for the special services, especially when it is considered that there were no files of drawings and data of previous steamboats to refer to. The double-end ferry boats wtih floating loading bridges, the Long Island fleet with curved lines for strength and seaworthy qualities for rough weather, the stern-wheel boats which he built for the Mississippi River, and finally the first successful steam warship, the "Demologus" (later named "Fulton I"), built with two hulls with the wheel in the centre and the sides protected with 5ft. of oak, was each a remarkable demonstration of his resourcefulness and ability as a naval architect and a marine engineer.

Fulton never made a secret of his plans. He claimed success by determining the horse-power of his engine by formula, based on the calculated frictional resistance of the hull at a predetermined speed. Each hull was designed to carry a definite weight of machinery and cargo. His United States patents fully describe these formulæ.

The many improvements in his arrangement of machinery are shown by referring to the drawing illustrating his 1810 patent, which was applied for one year after the first application. The titles given under the accompanying drawings are taken from the description of the two U.S. patents and show the progressive development from the first primitive model.

His career was brought suddenly to an end when he was fifty years of age. He was mourned as one of the geniuses and great men of the country. He was buried in the Trinity Church Yard in New York, but his grave was unmarked until 1901, when the American Society of Mechanical Engineers held a memorial service in the church, at which were presented addresses by George W. Melville, Rear Admiral and Engineer-in-Chief, U.S.N.; Commander B. F. Isherwood, U.S.N.; and Robert H. Thurston, of Cornell University. A memorial erected by the Society was unveiled on that day in the south-west corner of Trinity Churchyard.

Space in this paper does not permit discussion of other Americans who greatly contributed to the development of steam navigation, nor of the franchise secured by Fulton and his partner Chancellor Livingston from the New York Legislature for exclusive navigation of the waters of New York. These interesting events are given in the many biographies writen of Robert Fulton, our first marine engineer, and naval architect of steam vessels.

Speeds of Travel of the Future.*

By RAYMOND CARPMAEL.

COMPARISONS of present-day railway speeds with those of, say, forty years ago, are valueless without consideration of the important factor of greater weights hauled mainly for the comfort and safety of the passenger. It would, however, appear that the advent of the streamlined internal combustion engine-driven trains will result, if it has not already resulted, in the attainment of very high speeds with a maximum of comfort, although up to the present the carrying capacity does not approach that of the steam-hauled long-distance passenger trains.

* * *

In laying out a track such as that between Paddington and Swindon, which is for the most part straight and level, Brunel's foresight has rendered unnecessary the calling of a halt in an increase due to track limitation of what are generally even now regarded as high speeds, and the foresight of several of his successors in the railway world when constructing new railways has also been of similar benefit to the travelling public. What are these track limitations?

Foremost come those which may be imposed by the strength of the track itself, the essential constituents of which are the rails, their supports, and the structures and earthworks on which they are carried.

Modern railway track, with all its component parts, is constantly under scientific, theoretical, and practical review, and I will unhesitatingly say that our trunk lines fulfil all Mr. Whitelaw's speed ideals.

The British standard heavy-section rail of which all the group railway companies make use is of suitable carrying capacity, but research is constantly undertaken with the object of ascertaining the ideal metallic composition and contour both as to strength and wearing properties. I need hardly add that this ideal has not yet been reached, bearing in mind that it must be considered in conjunction with the problem of the wear of tires of locomotives and rolling stock.

Two of the supports for the rail, the chair and the sleeper, call for little comment beyond indicating that steel sleepers, carrying chairs either cast or welded on to them, appear to provide a good substitute for timber with smooth and quiet running.

The third support, the fish-plate at the joint, presents a real problem, and if it were to be entirely solved, travellers by rail would probably complain how they missed the familiar "thump thump" at every rail joint which we all know so well.

The latest joint improvement which all the railway companies are adopting is to use a short two-hole fish-plate with a correspondingly reduced spacing of sleepers on either side of the joint.

So far as our experience goes, we are nearer than we have ever been to the solution of the joint problem, though here, again, the problem is not one affecting to an appreciable extent the running of very high speeds, but one of day-to-day maintenance for all traffic.

No track, whether for medium or high speed, can be considered to be satisfactory unless it is efficiently drained and ballasted, and it must be taken as a *sine qua non* that high speeds cannot be permitted on tracks on which these provisions have not been made. Although safe running on poorly drained tracks may not be questioned, smooth and comfortable running over them can never be attained.

A great deal has been heard in recent times of impact and hammer-blow of locomotives, and there is, or has been, a tendency to provide in our bridge designs for a generous and ample margin of strength to meet this demand. The recent improvements in the balancing of the modern engine render such uneconomical provision unnecessary, and eliminate one of the main problems of the civil engineer when called upon to agree to high speeds.

As rails wear and sleepers decay, the necessary replacements are made to ensure that the track is of ample strength to carry at the required speeds all traffic passing over it.

Having dealt with some of the civil engineering aspects of speed on the railway, there remains the main problem for which the mechanical engineer—the designer of the locomotive and the rolling stock—is wholly responsible.

Up to the present, as has been indicated, except for a few isolated cases, development with steam traction has been in the direction of haulage of increased loads rather than attainment of very high speeds, and the maintenance over long distances of speeds of 60 m.p.h. is somewhat exceptional.

It cannot be overlooked that, in this direction, possibly due to the relaxation of governmental speed restrictions, Continental railways show a greater improvement than our own, where, for many years, we have maintained comparatively higher speeds.

This year three countries only—France, Germany, and Great Britain—provided regular daily service runs of 66 m.p.h. and over, totalling 1609 miles by thirteen trains. Of these, France claims 51 per cent. (820 miles, eight runs), Germany, 44 per cent. (712 miles, four runs), and Great Britain, 5 per cent. (77 miles, one run).

In daily service runs at speeds of 64 m.p.h. and over, the figures for 1934 are: Germany, 1641 miles (twelve runs); France, 1280 miles (twelve runs); and Great Britain, 230 miles (two runs); total, 3151 miles (twenty-six runs). In 1933, the comparable figures at speeds of 64 m.p.h. and over are: France, 1040 miles (nine runs); Germany, 712 miles (four runs), whilst the British total remains unaltered, and in no other Continental country were such speeds attained.

* * *

The attainment of high speeds by all forms of transport is no longer a dream.

What is the real difficulty? It is undoubtedly that of practicability of the maintenance with safety of such high speeds over prolonged distances, neglecting for the moment the economic aspect of the problem as affecting those common carriers, the railway companies.

What are the technical difficulties?

On our railways there are, on the civil engineering side, mainly the alignment of the track and its gradients and its correct maintenance, the incidence of junctions—particularly where the curvature is adverse, and the appropriate "cant" or rail superelevation.

On the mechanical engineering side they are the provision of the suitable tractive power and the most suitable rolling stock to ensure maximum comfort at maximum speed.

Although on the Great Western Railway my responsibilities do not include those of signalling, these normally fall within the province of the civil engineer, and it cannot be emphasised too strongly that the operating departments depend to a very great extent on the signal engineer for the regular maintenance with safety of high speeds for prolonged distances.

* * *

A difficulty which, perhaps, is more geographical than technical, and one which exists to a greater or lesser extent on all the railways of the world, is the incidence of level crossings—that is to say, the crossing on the level of the railway of roads whether public, private, or accommodation (farm, &c.). This difficulty can only wholly be solved by the construction of bridges to carry the roads over the railway with no interruption of traffic.

Apart from technical difficulties, come those of the operating department whose province is to determine the appropriate provision of block sections of suitable lengths for traffic requirements, and to justify the necessity for high-speed tracks through stations, independent of those for local services, of relief tracks ample to carry traffic moving at comparatively slow speeds, &c.

In addition to what may be described as normal difficulties are those due to natural causes—slips, floods, gales, fog.

Having indicated the difficulties as affecting the railways, some mention should be made of the practical methods of overcoming them.

The civil engineer, neglecting once more for the moment the economic side, finds no technical difficulty in the adjustment of alignment and gradients; the transitioning of approaches to sharp curves to ensure that the full superelevation (cant) can be given on the true curves; and the provision of fly-over junctions to avoid the crossing of one track by another on the same level, but often finds that the physical conditions governing track lay-out may be of such a nature that speed restrictions of a greater or lesser degree are unavoidable.

* * *

The comparative scarcity of the flying junction in this country is chiefly explained by the high cost of the works, and of that of the additional land needed for their construction. There are, however, several examples, and no new high-speed lines should be constructed without them. The reconstruction work recently carried out at Taunton on the Great Western Railway provided a welcome opportunity to abolish the "flat" junctions—the crossing of lines on the level—by laying down four lines at Cogload Junction and carrying the down line from Bristol over the lines to and from London, thus permitting four trains to run simultaneously through the site of the former junction.

* * *

It is a recognised and well-proved axiom that the attainment of increases in speeds beyond certain defined limits can only be realised by increases in expenditure, both in the first cost of the machine and in its running costs. To give one example alone, each car unit of high-speed Diesel streamlined trains involves an expenditure approximating to £15,000, a figure out of all comparison with those of the railway passenger coach and its locomotive.

The problem, therefore, becomes an economic one primarily affecting the general managers rather than the engineers, mechanical and civil.

* * *

The more one examines the question the more one realises that the problem of travel speed in the future is not one of attainment, but of maintenance of high speeds with safety and comfort over considerable distances, whether one thinks in terms of trains, motor cars, ships, or aircraft.

Apart altogether from efficient engine performance one cannot overlook, although we endeavour to overcome them, physical difficulties, and, with railways in particular, those of operation.

Of the physical difficulties the greatest is unquestionably fog.

On the railway, the various safety devices—high-powered colour-light signalling, the power-controlled operation from considerable distances of both switches and signals, track circuiting, detonator placer machines, and the automatic train control ramp—have been evolved.

* The Institute of Transport. Excerpts from a paper read in London on November 12th, 1934.

SIXTY YEARS AGO.

BOILER explosions are fortunately much less frequent and, when they occur, commonly much less disastrous than they were sixty or more years ago. We may therefore record for the benefit of a generation of engineers which, happily, knows little about them, the circumstances of an alarming explosion which occurred at Leeds on November 4th, 1874, and of which an account was given in our issue of November 20th of that year. The boiler involved was situated at the centre of a large wood yard in Skinner-lane, belonging to Mr. Thomas Hall, a timber merchant. The explosion occurred at 9.30 in the morning. The building in which the boiler was situated was destroyed and the engineman who was in it at the time was blown a distance of thirty to forty yards and instantly killed. Two other men were severely injured and there were several cases of minor injury. Otherwise the accident was remarkable for the way in which property and life escaped from its great force. Parts of the engine were hurled to a distance of a quarter of a mile but without doing serious damage. A portion of the chimney stack fell on a house opposite the wood yard. It tore a large hole in the roof but went no farther than a bedroom on the upper floor and all the inmates escaped. Another portion of the chimney fell harmlessly about 150 yards away. The boiler shell remained practically intact. It measured 16ft. long by 6ft. in diameter and was lifted 40ft. in the air and projected over a whole row of dwelling-houses into an adjoining street fully a hundred yards distant. In falling it struck a corner of the last building in the row but two children who were in the room which it damaged escaped unhurt. Proceeding a little farther it struck the roof of a drying shed of a nearby warehouse and after demolishing the gable end of this shed came to rest half inside the building and half in the street. Men were at work in the shed at the time but they saw the boiler coming "like a balloon" through the air and had time to make good their escape. At the inquest it was made clear that the explosion had been caused by the faulty construction of the boiler. The boiler was inherently weak as a result of insufficient staying of the internal flue or fire-box. This weakness had been aggravated by the quality of the workmanship and the total ignorance of boiler construction displayed in effecting certain repairs. The jury found that the boiler had exploded by over-pressure and strongly recommended that in the interests of public safety all boilers should be placed under independent inspection. We questioned whether that verdict fully met the circumstances of the case.

BOOKS RECEIVED.

This Modern World and the Engineer. Edinburgh: Royal Scottish Society of Arts, 16, Royal-terrace. Price 5s. net.

Torsional Vibration. By W. A. Tuplin, M.Sc. London: Chapman and Hall, Ltd., 11, Henrietta-street, W.C.2. Price 21s. net.

Zerspanung und Werkstoff. By Dr.-Ing. E. Brödner. Berlin: V.D.I. Verlag G.m.b.H., Dorotheenstrasse 40, N.W.7, Germany.

The Spirit of Chemistry. By A. Findlay. London: Longmans, Green and Co., Ltd., 39, Paternoster-row, E.C.4. Price 10s. 6d. net.

Textbook of Mechanical Engineering, 1934. London: His Majesty's Stationery Office, Adastral House, Kingsway, W.C.2. Price 12s. net.

The Testing of Bituminous Mixtures. By D. C. Broome, F.C.S., and R. D. Childs. London: Edward Arnold and Co., 41 and 43, Maddox-street, W.1. Price 15s. net.

Water Power Engineering. Second edition. By H. K. Barrows. London: McGraw-Hill Publishing Company, Ltd., Aldwych House, Aldwych, W.C.2. Price 36s. net.

The Submarine Cable. By Captain S. A. Garnham and R. L. Hadfield. London: Sampson Low, Marston and Co., Ltd., 100, Southwark-street, S.E.1. Price 10s. 6d. net.

Percussion Drilling Rigs and Tools for Shallow Water Wells. By W. M. Jennings, B.Sc. London: The Technical Press, Ltd., 5, Ave Maria-lane, E.C.1. Price 10s. 6d. net.

Hydraulics. Second edition. By E. W. Schoder and F. M. Dawson. London: McGraw-Hill Publishing Company, Ltd., Aldwych House, Aldwych, W.C.2. Price 21s. net.

Railway and Road Matters.

THE President of the Permanent Way Institution for the ensuing year will be Mr. W. K. Wallace, the chief engineer of the L.M.S. Railway.

THE matter of a locomotive testing plant in this country was mentioned in the House of Commons on November 12th, when the Minister of Transport, answering a question, said that the subject was now again being considered by the Department of Scientific and Industrial Research, in conjunction with the railway companies.

IN an article on Research on the Railways, in the *Railway Newsletter* for November, it is said that an investigation has just been completed into the origin and distribution of dust in trains, revealing that about half the dust is blown up from the ballast on the track, the other half coming from the chimney of the locomotive.

THERE was an unfortunate accident to a gang of platelayers near Swindon Station, G.W.R., on November 13th, in which three men lost their lives. It will undoubtedly be inquired into by one of the assistant inspecting officers of the Ministry of Transport. Meanwhile, we would say that Rule 234 provides that when a train is approaching, men at work on the permanent way must not remain on any running line but at once stand clear of all lines, unless they can distinctly see that they are in a position of safety and in no danger from another train approaching them unobserved.

ANSWERING a question addressed to him on November 12th, Mr. Hore-Belisha said that the Standing Joint Committee of the four main companies and of the London Passenger Transport Board had decided that in the event of any electrification in the London suburban area of the L.N.E.R. being done, the lines based on Liverpool-street would have the priority over those radiating from King's Cross. Pressed to consider the "hopelessly inadequate travelling facilities" in the area served by King's Cross, the Minister of Transport said that he had already done what he could by representing the matter to the Transport Board, but he could not exceed his powers.

SOME important changes are being made in the administration of the engineer's department of the London and North-Eastern southern area. Under the chief engineer for the area, Mr. C. J. Brown, there is an assistant engineer (maintenance) and an assistant engineer (construction). The latter position is held by Mr. R. J. M. Inglis, who has now been appointed the assistant engineer for the area. The office of assistant engineer (maintenance) has been filled by Mr. E. L. Hawkins, who joined the Great Eastern in 1892, and thus has had forty-two years' service, is about to retire. Mr. Hawkins will be succeeded on January 1st by Mr. J. C. L. Train, now the district engineer for the western district of the Scottish area.

ACCORDING to the Railway Returns for 1933, the daily average number of steam locomotives that were available for service and were in use was 90·82 per cent. of the total. That figure compared with 89·33 per cent. in 1932. From this consideration there are excluded the locomotives in serviceable conditions that had been withdrawn from service and stored. It is, we would remark, gratifying to find that while these withdrawn engines numbered 1135 at the end of 1932, they had been reduced to 639 by the end of 1933. The engine hours "in traffic" per steam locomotive in use per week-day were 12·04 in 1933 as against 11·68 in 1932, and the engine miles run per steam locomotive in use per week-day were 106·35, compared with 102·97.

WITH but a few months to go to complete sixty years of active service on the L.M.S. Railway, one of the most historic locomotives in Britain has been withdrawn from traffic and will shortly finish her career in the breaking-up shop at Crewe works. She is engine No. 25001, "Snowdon," and for some time past she has been the sole survivor in active service of the famous "Precedent" class engines of 1874, more familiarly known to successive generations of railwaymen as the "Jumbos." There were in all 166 engines of this type, some of which survived in L.M.S. service until quite recent years. In their prime they worked the heaviest and fastest Scottish expresses, and during the "Railway Race to Scotland" in 1895 the "Hardwicke" engine of this type ran a racing train from Crewe to Carlisle, 141 miles, including the Shap Summit of 915ft. above sea level, in 126 minutes at an average speed of 67·2 m.p.h. "Hardwicke" herself was withdrawn from active service in 1932 and is being preserved by the L.M.S. as a locomotive of historic value and interest.

WHAT we consider to be the most complete account of the history and details of the Cromford and High Peak Railway appears in the November issue of the *Railway Magazine*. It was written by Messrs. D. S. Barrie and J. R. Hollick. It opens with a quotation from W. Adam's "The Gem of the Peak," which said that "the High Peak Railway . . . is an interesting object; exhibiting a fine specimen of those intellectual energies given by a gracious God to man; and a striking proof of that passage that 'knowledge is power'; for who would have thought of a railway over such acclivities and apparently inaccessible tracts?" Herein, and in other articles on this remarkable work, we have failed to find any reference to an incident which occurred at the Cromford end of the line about the middle 'nineties. Some wagons, when either ascending or descending the 1 in 8 Sheep Pasture incline, broke away from the cable. They attained such a speed that when they left the road they were thrown into the air and over the canal, the Derby–Matlock main road and the Midland Railway, and landed in a field. This, we believe, led to the provision of the large catch-pit, the stationing of a pointsman to watch the speed of trains, and the automatic gongs referred to in the article. The illustration of High Peak Junction, where the line has a connection with the L.M.S. Derby and Manchester section, reminds us that immediately north of that junction the latter line crosses the river Derwent, passes under the Ambergate and Cranford Canal, through Lea Wood tunnel, under the Lea Bridge arm of the Canal, and again over the Derwent; all within a distance of about half a mile. The arm of the canal, just referred to, has its terminus in the village of Lea, which was visited by the Newcomen Society on Friday, June 8th last.

Notes and Memoranda.

DISCUSSING a paper, "Cast Iron for Chemical Plant," by Mr. J. G. Pearce, before the Chemical Engineering Group, Mr. W. Russell, speaking of corrosion testing, emphasised the absolute necessity of working with works solutions instead of synthetic solutions. Again, the loss of weight alone was not always a sufficient test, for it was known that there had been a great loss in strength, in certain cases, and yet not a corresponding loss in weight.

A PAPER before the Institution of Electrical Engineers of Japan, by Mr. Choji Suzuki, contains the results of experiments conducted to investigate the deterioration of copper oxide rectifiers owing to temperature rise. The conclusions obtained from the experiments are:—(*a*) Unless the temperature of the rectifier is raised above 80 deg. Cent., any appreciable deterioration does not occur; (*b*) if the temperature is raised above 85 deg. Cent., the deterioration begins to appear; when raised over 100 deg. Cent. deterioration becomes more severe, and above 120 deg. Cent. rectification is almost lost.

AN extract in the *Iron and Coal Trades Review* describes a new nickel-beryllium alloy which can be tempered by precipitation hardening so that it has a tensile strength of 259,000 lb. per square inch, with a yield point of 219,000 lb. per square inch, and an elongation of 8 per cent. Its Brinell hardness is then 460. Another alloy of beryllium with both nickel and chromium present has, after age-hardening, a tensile strength of 216,000 lb. per square inch, an elastic limit of 204,000 lb. per square inch, and an elongation of 11 per cent. It is stated that both of these alloys possess unusual corrosion-resistance properties with special reference to resistance to mineral acids at temperatures causing intergranular corrosion in some existing materials or alloys.

AN estimate by the Union Française des Producteurs de Benzols gives the production of benzole in the eleven principal producing countries of the world last year as 918,400 tons, after the 829,500 tons of 1932 and the 1,019,700 tons of 1931. Between 1932 and 1933, output in the U.S.A. recovered from 270,000 tons to 320,000 tons; in Germany, from 250,000 tons to 275,000 tons; in England, from 118,000 tons to 119,000 tons; in France, from 68,200 to 74,200 tons; in Poland, from 17,000 to 18,000 tons; and in Holland, from 21,500 to 23,000 tons. Output in Czecho-Slovakia was stationary during the two-year period at 14,000 tons per year, the same being true for Italy with 5000 tons and Spain with 3200 tons. The figures should be accepted with a certain amount of reserve, states the *Chemical Trade Journal*, as in some cases they cover crude benzole and in others light oil distillation products as a class.

AN article in *Steel* gives particulars of some economies due to the use of a chromium-molybdenum-vanadium non-deforming, deep-hardening steel for blanking dies for tinplate. This steel contains 12·50 per cent. chromium, 0·80 to 1·00 per cent. molybdenum, 1·00 per cent. vanadium, and 1·60 per cent. carbon. For blanking can ends of various sizes the dies are of the double type, producing two pieces per stroke; the automatic presses make 18,500 ends per hour. The dies are capable of producing 3,500,000 end blanks between re-grindings, and can be re-ground eight times with one complete re-working between the fifth and sixth periods of use. The total die life averages 35,000,000 can ends. With the steel formerly used, life between re-grindings averaged only 1,000,000 blanks and total production per set was thus 10,000,000. Re-grindings were at the rate of 500 a year, as compared with only 143 with the chromium-vanadium steel.

DESCRIBING a motor converter breakdown in the *Electrical Times*, "F. D. P." says that on running up a 500-kW, twelve-phase, 6·6-kV cascade motor converter it was discovered that a coil in one of the stator windings had broken down, the trouble being detected by severe local vibration and hum, the former being caused by the formation of a local closed magnetic circuit and the nature of the fault, which had not broken down to earth, but just short-circuited two coils of almost similar potential. The machine was taken apart and after the faulty coils had been detected and re-insulated the machine was once again placed in commission. About two years later exactly the same fault occurred. It was then ascertained that one of the current limiting starting resistances which were connected in parallel across the contacts of the 6·6-kV oil switch had become open-circuited, resulting in an unbalanced current being applied to the stator phases momentarily on switching in. This repeatedly occurring had had a deteriorating effect on the stator coils concerned, with the above result. The periodical testing of such resistances cannot, therefore, be too strongly emphasised.

THE effect of oxygen-free atmospheres (nitrogen and hydrogen) upon the wear of a hypoeutectoid, a eutectoid, and a hypereutectoid carbon steel has been studied at the U.S. National Bureau of Standards. It was found that when these steels were hardened and subsequently tempered at low temperatures the rates of wear were comparatively low; the wearing surfaces were smooth and were covered by a thin oxide film and the abraded particles consisted of Fe_2O_3 and Fe_3O_4. When these steels were tempered above certain temperatures the rates of wear were extremely high; the worn surfaces were very rough and bright and the abraded particles were metallic iron. Microscopic examination showed that those steels which had rough, film-free worn surfaces had severely distorted structures adjacent to these surfaces. In the case of steels which showed only the filmed worn surfaces the structures adjacent to these surfaces were not greatly changed by the wear test and the worn surfaces themselves were smooth. The severely distorted structure was also observed in the case of certain steels which showed characteristics of both types of wear. Numerous cracks intersecting or approximately parallel to the worn surfaces were observed in the micro-examinations of both types of surfaces. These tests indicated that a film of either ferric or ferroso-ferric oxide on the wearing surfaces of carbon steels results in a certain degree of protection against wear, probably by preventing actual metal-to-metal contact. When these films are absent severe wear takes place.

Miscellanea.

THE death has been announced of Professor Karl von Linde, the inventor of the ammonia compressor and one of the pioneers of refrigeration.

A REPORT states that the Pennsylvania Railroad has ordered fifty-seven streamlined electric locomotives capable of a speed of 90 miles an hour.

THE liner "Celtic Star," of 5574 tons gross, which recently berthed near London Bridge, is the largest liner that has travelled so far up the Thames.

THE first dry dock in China north of the Yangtze River was opened at Tsingtao in October. It has a length of 480ft., a width of 78ft., and a depth of 23ft.

THE White Star liner "Adriatic," now lying at Liverpool, has been sold to Japanese shipbreakers for £65,000. She is of 24,679 tons gross, and was built in 1906.

THE bulletin of the U.S.S.R. Chamber of Commerce states that 1415 ships have passed through the Leningrad Harbour this year, as against 1048 for the same period last year.

THE output of coal for the current year is, up to date, 13 million tons in excess of that for the same period of 1933. Mr. W. R. Gordon, of the Coal Utilisation Council, states that this year's output will probably be 15 million tons higher than last year's.

THERE has been a substantial increase in the sales of electricity in the Irish Free State, according to the report of the Irish Free State Electricity Supply Board for the year ending March 31st, 1934; 138,503,130 units were sold, as against 120,098,523 units last year.

THE North German Lloyd liner "Bremen," on her 100th westward crossing, broke the Transatlantic record on November 8th, when she passed Ambrose Light 4 days 15 h. 27 min. after leaving Cherbourg. The previous record was 21 min. slower and was also made by the "Bremen."

AT the annual general meeting of the Junior Institution of Engineers (Incorporated), held on November 9th, 1934, Mr. H. P. Wright was elected Chairman of the Institution for the present session and the following officers were elected:—Vice-Chairmen, Hon. Treasurer, Hon. Editor, Hon. Librarian, Councillors, Hon. Auditors.

AT the ordinary general meeting of the Institution of Petroleum Technologists, held on November 13th, the President announced that Sir John Cadman, G.C.M.G., Hon. LL.D., D.Sc., had been unanimously elected President for the session 1935–36, to take office immediately after the annual general meeting on March 12th, 1935.

ACCORDING to Mr. T. Stewart Lyon, Chairman of the Hydro-Electric Power Commission of Ontario, the Commission will study means of producing cheap oxygen and hydrogen as an outlet for its surplus electrical energy. It is believed that an abundant supply of oxygen and hydrogen at low cost would do much to develop Ontario industrially.

IN his presidential address before the British Road Tar Association, Sir David Milne Watson said that in the U.S.A. there are 24 million road vehicles using 3 million miles of highway. France has 2 million road vehicles using 440,000 miles of highway; Italy has 116,000 miles of highway, with 340,000 vehicles, and Germany 216,000 miles of highway with 700,000 vehicles.

THE Hetch Hetchy aqueduct, which has been constructed between the Sierra Nevada Mountains and San Francisco, was put into operation at the end of October. The aqueduct was described in THE ENGINEER of April 6th and 13th, 1934, and marks the completion of the 100-million-dollar water supply development which has been under construction for twenty years.

THE figures relating to the exports of oil engines from this country become increasingly favourable, says the *Oil Engine*. For the first nine months of 1934 the value of stationary oil engines exported from the United Kingdom was 42 per cent. higher than during the corresponding period in 1933, and 52 per cent. more than in 1932. The actual value from January to September 30th this year was £1,347,427.

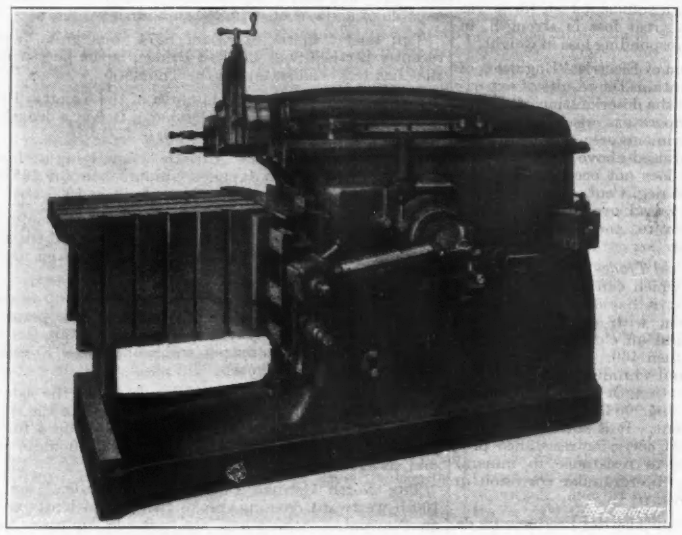
IT has been announced that the Western Chemical Company (Paisley), Ltd., has commenced the manufacture of solid carbon dioxide to be marketed under the trade name "Cardice." A Maiuri patent plant has been installed, and it is anticipated that during the peak demand of the summer months three shifts of men will be employed on the process. The carbon dioxide gas utilised is produced in the firm's works from magnesite.

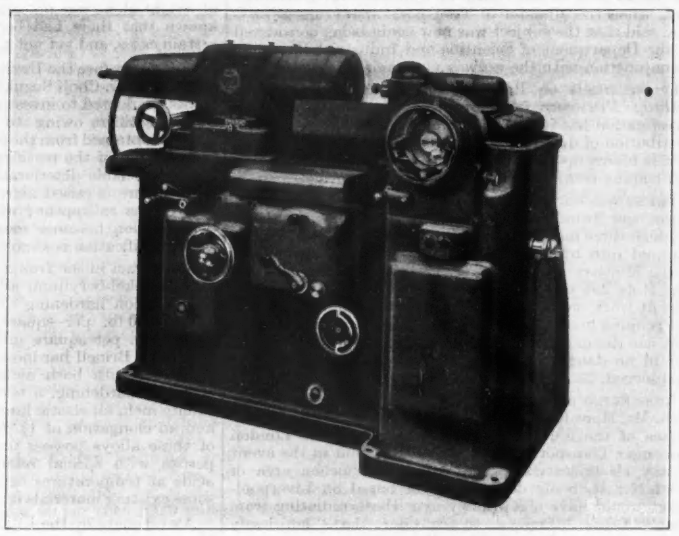
IN reply to a question in the House of Commons as to the total value of the work allocated to the Tyne and Clyde, respectively, under the naval programmes of 1932–33, 1933–34, and 1934–35, Sir B. Eyres Monsell said the approximate figures for the hulls and machinery of ships included in the programmes mentioned are: Clyde, £6,000,000; Tyne, £2,900,000. In addition, orders for armour, gun mountings, guns and engines have been placed to the approximate value of: Clyde, £300,000; Tyne, £1,300,000.

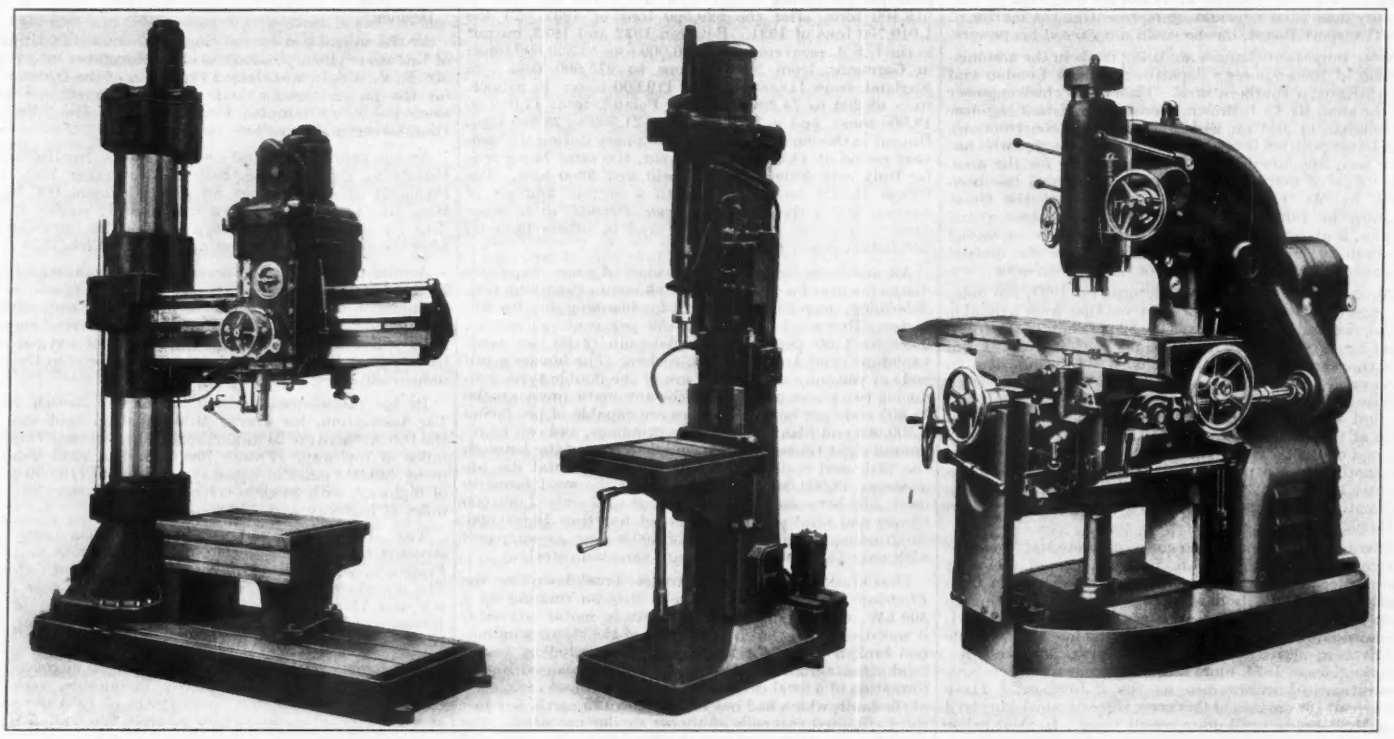
IT has been decided that the "Normandie," which is now approaching completion at St. Nazaire, shall be the first large French liner to have her four propellers driven by separate electric motors, deriving power from high-speed steam turbo-alternators, says the *Electrical Review*. The vessel, which has a length of 1030ft., and a tonnage of 75,000, is being equipped by the Alsthom Company, of Belfort, with four steam turbines directly coupled to 33,400-kW, three-phase A.C. alternators generating at 5500–6000 V and 2430 r.p.m., the battery of twenty-nine Penhoët boilers operating at 500 lb. per square inch. Power will be transmitted by single-coil cables at frequencies ranging between 60 and 81 cycles per second to the four motors, each designed to develop 40,000 H.P. at 243 r.p.m. Under normal conditions they will operate synchronously, but they are designed to act on starting and up to a fourth of their normal speed as asynchronous machines. It will be possible to run them asynchronously at higher speeds, but only for very short periods.

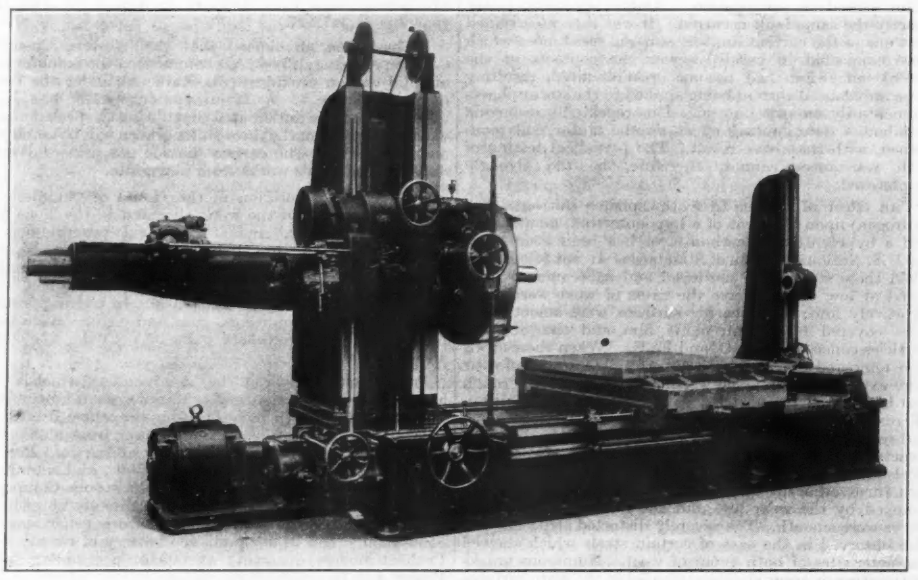
MACHINE TOOLS EXHIBITED AT OLYMPIA

(*For description see page 505.*)









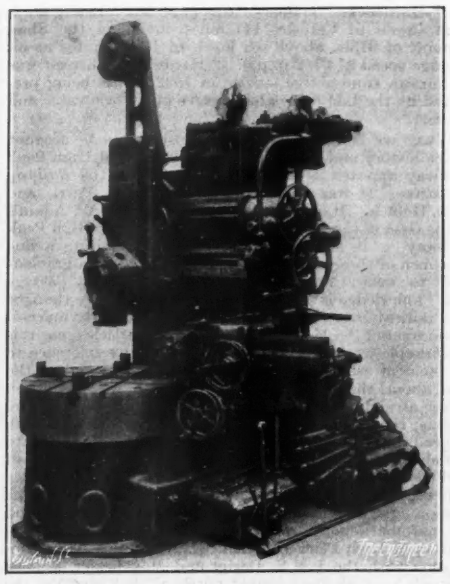


FIG. 42 (TOP)—SHAPING MACHINE—WOTAN FIG. 43 (TOP)—INTERNAL GRINDER—WOTAN

FIGS. 44, 45, 46 (CENTRE)—RADIAL DRILL; DEEP-HOLE DRILLING MACHINE; AND 30-INCH VERTICAL MILLER—ARCHDALE

FIG. 47 (BELOW)—BORING, SURFACING AND MILLING MACHINE—RICHARDS FIG. 48 (BELOW)—36-INCH VERTICAL TURRET LATHE—WEBSTER & BENNETT

The Engineer

NOVEMBER 23, 1934.

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NOTICES TO READERS.

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FIRST PRINCIPLES.

WE are confident that very many of our readers must have read with pleasure the little address with which Dr. Thornton opened the present session of the Informal Meetings of the Institution of Electrical Engineers, and which was reprinted in our issue of November 9th. His subject was "First Principles," and his treatment showed breadth of view struggling with the developed inclinations of a professor to be dogmatic. First principles are not unlike other principles. They may lead us into excesses and provoke troubles if not used in moderation. In other spheres than science they have led men to the stake, and they brought Galileo within sight of martyrdom. Fortunately for the world, he had the wisdom to sacrifice his belief at the last moment, easing his conscience with a *sotto voce* mental reservation. Feeling that whatever he chose to aver or withhold the world would still move round the sun, he came to the very philosophical conclusion that it was not worth dying for his first principle. Time justified him, as it always does when fundamental truths are concerned. In these days we have no stake to enforce conformity to orthodox beliefs. Opposing feelings may run high, but no one is even singed for his opinions, and the more philosophical trouble their heads but little about first principles, if by using orthodox errors with judgment they can make a living.

The fact is that at any given time workable hypotheses serve the purpose of the day. In our last issue Professor David hinted that our estimates of the highest attainable efficiency of internal combustion engines may be based on faulty determinations of the specific heat of gases at high temperatures. But he admitted that no one was a penny the worse. As long as the same basis of comparison is used by all, relative merits remain just where they were. As Dr. Thornton said: "It is what is thought to be true *now* that matters." Of course, there is a danger in such complaisance; but it is not a real danger. Those who like to raise bogeys may try to frighten us with visions of a world petrified by its adherence to accepted hypotheses. But we know that their bogey is a hollow turnip dimly illuminated by a halfpenny dip. More danger is to be anticipated from the overthrow of established errors than from the likelihood that the search for still more and more profound "first principles" will ever abate. Here we apply purposely the comparative degree to a fundamental; for do we not all recognise that the first principles of to-day may not be those of to-morrow? Has not Einstein dethroned Newton? "Science," to quote once more from Dr. Thornton, "lives and moves entirely in its wave front. . . . it advances like a meteor, which throws out of its advancing head all the used-up products of combustion, with a profusion that often startles the observer." By that "profusion" all risk that the world will grow old in errors is removed. But it causes the unrighteous to blaspheme. "Since science is continually changing" they say "we will have nought of it." Not an unreasonable attitude. When two doctors differ there is not much advantage in following the advice of either. "Give me," said Napoleon, "one indifferent general, rather than two good ones." To the practical world a positive workable hypothesis is generally of more importance than a first principle. The thing that it dreads most is that it may be upset by new fundamental discoveries to which it is unable at once to attune itself. Imagine, for example, the confusion that would arise, and the resentment that would be aroused if the first principle implicit in Ohm's law were suddenly challenged! Fortunately, there is little or no danger that the old-established laws of Nature will ever be so seriously shaken by new discoveries as to invalidate their employment in the ordinary affairs of the world. In all practical essentials the laws of science rest on the bed-rock foundation of experimental verification. The discovery of new "first principles" may, and will, help us to understand these laws better, and to make more intelligent use of them, without endangering the existence of the laws themselves.

Science has been built up on two philosophies—the subjective and the inductive—and which of the two is the greater none shall say. From Dr. Thornton's final paragraph one might be led to believe that he leans towards the subjective. He puts forward the suggestion that great unifying ideas should be put into the minds of students and that they then should be instructed to fit the facts to them. "What is wanted quite early on in all scientific training is to indicate that there are great sweeping laws that gather together masses of apparently disconnected facts like fish into a net. Tell students, if possible, what those laws are and mean, and then let them acquire facts and fit them into place, rather than give them masses of facts first to sort out later in life." That is a rather grand conception of an educational method, but does it not imply that the teacher himself is quite confident about his first principles, and is certain that they will be confirmed by experiment? Would it not lead us, if followed to its logical end, back almost to mediæval conditions in which the scholar might gain honour by the justification of the first principles laid down by the Church, but could only gain the prison or the stake by expounding opinions opposed to those first principles? We are entirely in accord with Dr. Thornton that the recognition of "great sweeping laws" should be in every way encouraged, for in no other way can we hope to counteract the evils of close specialisation; but we ask—leaning, ourselves, towards the Baconian method—should not the experiments come first and then the scholar be encouraged to recognise the great unifying laws which bind them into one?

The Steel Trade's New Leader.

WHEN the National Federation of Iron and Steel Manufacturers—the parent of the British Iron and Steel Federation—was formed just after the war, its members would have been astonished could they have foreseen the direction in which it would develop. The original Federation came into existence largely as a result of the close association of manufacturers during the war, when they were frequently called upon to meet the officials of the Ministry of Munitions and other Government Departments on matters concerning prices, the production of war material, and similar affairs. The difficulties of the steel industry may be said to have begun soon after the Federation was formed, and to-day few would deny that its establishment was one of the wisest steps the industry has ever taken. Throughout the long years of trade depression, amid new and perplexing industrial problems and all the economic upheavals of the post-war period, the Federation, under the guidance of Sir William Larke, proved its worth and held the British steel industry together as no similar organisation had previously been able to do. It was a source of strength that whilst several associations representing sections of the trade met at the Federation offices to discuss the question of prices, the organisation was by its constitution unable to become involved in these or other commercial details. The coming of Protection, however, and the determination of the Government that in return for high import duties on foreign steel the British industry must reorganise itself, introduced new circumstances and new requirements. It became evident that a central organisation with wider powers than those of the National Federation, and one which could direct and control the commercial side of the industry, was necessary. The adoption of a constitution for the iron and steel trades and the metamorphosis of the National Federation of Iron and Steel Manufacturers into the British Iron and Steel Federation in April last is recent history. Since then the gradual reorganisation of the industry has been proceeding, although not perhaps so rapidly as some critics have thought desirable. Within the last few days, however, the Independent Chairman provided for in the constitution has been appointed in the person of Sir Andrew Duncan, and this marks a definite step in the scheme of reorganisation.

By intimating that the Chairman of the Federation should be unassociated with the steel trade, the Government ruled out a number of distinguished figures whose knowledge, ability, and services to the industry would have admirably fitted them for the post, but, on the other hand, it would have been difficult to find a leader more suitable from the point of view of achievement and experience than Sir Andrew Duncan. He belongs to the new type of business man, better described, perhaps, as industrial administrator, and his career has covered a successful association with the shipbuilding, coal, and electrical industries. He comes fresh from the reconstruction of the electricity supply industry, in which he has played a great part as Chairman of the Central Electricity Board, to tackle somewhat similar problems connected with iron and steel. That Sir Andrew is a man of great energy may be gathered from the fact that whilst the reconstruction of the electricity supply industry is so far advanced that its leaders may to some extent rest upon their laurels, Sir Andrew will have again to take up the spade work which is inevitable in the early stages of industrial reorganisation. The newly constituted Federation embraces not only the basic trades of pig iron and steel making, but branches of industry which manufacture finished products, such as tin-plates and galvanised sheets, and also users of iron and steel, such as constructional engineers. It will be the part of the Chairman of the Federation to preside at meetings at which the divergent interests of these branches—which, in effect, are trades in themselves—are discussed and to hold the scales of justice. It is an open secret that the claims of groups of steel works and individual steel makers within the Federation are far from being satisfied, and, in addition, there is the problem presented by successful manufacturers who are outside the organisation. Perhaps the question which holds the greatest national significance, however, is the attitude of the Federation to the proposed alliance with the European Steel Cartel. For the moment it would appear that there is a pause in the negotiations, which are the more delicate because of the uncertain relations existing between the various national blocs which form the Cartel. There is also, according to report, a wide difference between the share of the British market which the Continental steel makers have asked for and that which the British steel makers are prepared to give them, amounting to about three-quarter of a million tons. In addition, the financial situation in Germany and the barter trade which that Government is endeavouring to develop have a definite bearing upon the Continental steel situation which is the more difficult to control from the fact that the Cartel agreement must be renewed before the end of next March or the organisation will be automatically dissolved. These and similar problems and their bearing upon the home and international trade situation will have to be considered by the Federation in the not distant future.

In accepting the responsibilities of the Chairmanship of the British Iron and Steel Federation, Sir Andrew Duncan has undertaken not one but many tasks, which might daunt even a man of his undoubted courage. But in spite of the divisions in the trade, and the competition of individual works in the markets, there is a strong spirit of loyalty to the industry amongst British steel makers, and

it will prove an asset in the work of reorganisation which has yet to be done. It is probable that the relations of the Government and the steel makers will be improved now that the appointment of a Chairman has been announced, since it has been understood for some time that the slow development of the reconstruction plans was causing concern in official quarters. Perhaps the assurances of an independent Chairman may go some way to convince those who under-estimate the difficulties of the task, and at the same time placate those within the industry who regard with a considerable degree of coldness some of the reorganisation proposals.

High-Pressure Hydrogenation Plant.

THE INSTITUTION OF MECHANICAL ENGINEERS.

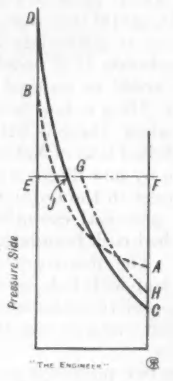
THERE was nothing to criticise and little that was contentious in the paper entitled "High-pressure Plant for Experimental Hydrogenation Processes" which Messrs. A. T. Barber and A. H. Taylor presented before the Institution of Mechanical Engineers on Friday evening, November 16th. The paper, a reprint of which is begun elsewhere in this issue, describes some of the engineering and metallurgical difficulties encountered at the Fuel Research Station, Greenwich during the development of experimental plant for the hydrogenation of coal and tar.

It may perhaps here be remarked that the chief difficulty encountered was a metallurgical one namely the disintegration, after a short life, of the steel reaction vessels under the attack of hydrogen at a pressure of three to six thousand pounds and at a temperature of anything up to 950 deg. Fah. This disintegration, or hydrogen embrittlement as it is alternatively called, has resulted in the explosion of the vessels, or in reducing them to the point of exploding, and had it not been overcome would certainly have jeopardised the commercial possibilities of the hydrogenation process as applied to the production of oil from coal. Special alloy steels were found to be more resistant than mild steel to hydrogen attack but the results which they gave were hardly in all respects satisfactory. The real solution of the problem came when it was fully realised that the hydrogenation of coal is an exothermic process and that once the reaction temperature has been reached the process will continue if the loss of heat from the vessel does not exceed the heat developed exothermically. Dr. Bergius and other early workers in the field knew that the process was exothermic but, we understand, the extent of the exothermic reaction was not at one time fully realised. When it was found to be as considerable as it really is the possibility of heating the reaction vessel internally instead of externally was opened out. By this change the walls of the vessel, lined internally with thermal insulating material, are protected against hydrogen attack and are called upon to withstand the high pressure at a considerably reduced temperature. Difficulties, we believe, have arisen in obtaining a satisfactory material for the insulation lining for any substance which depends for its insulating properties upon its porous texture loses much of its insulation efficiency when it is compacted by the high pressure prevailing inside the reaction vessel. Progress, we gather, has been made with the solution of this problem and at the I.C.I. works at Billingham which are now rapidly approaching completion internally heated vessels will be employed.

Professor C. H. Lander, as the former director of the Fuel Research Station, was fittingly called upon to open the discussion on the paper. At one time, he said, the work appeared to be very hopeless. Dr. Bergius had been studying the hydrogenation of coal since 1910 and in the early days had been stigmatised as a chemical adventurer and to have anything to do with him or his process was by many considered undesirable. In the face of all difficulties and discouragement he had, however, persevered and last year in recognition of his work he was awarded a Nobel Prize and during the past few days had received the Melchett Medal from the Institute of Fuel. The discovery and exploitation of the exothermic character of the reaction was the crucial factor which had made the process commercially practicable. Another major difficulty, which he believed still provided a constant source of trouble at the Greenwich station, was encountered in connection with the pressure gauges which were required to withstand and register the very high pressures employed. The work which had been done on the development of the process at the Greenwich station was of a highly dangerous kind, but he was glad to be able to report that it had been carried out without any serious mishap. There had been only one fatality at the station and it had been the result of a man falling from some scaffolding and not of anything to do with the hydrogenation experiments. Without in any way wishing to appear as an alarmist he would like to impress upon mechanical engineers the fact that the high temperatures and pressures now being employed in steam generators were approaching the conditions prevailing in a hydrogenation reaction vessel. Dissociation of the water might occur in which case the oxygen might cause corrosion and the hydrogen produce disintegration of the steel.

Professor F. C. Lea asked the authors for farther information concerning the resistance to hydrogen attack displayed by 3 per cent. nickel steel and concerning the precise composition of the nickel-chromium and chromium-molybendum steels with which they had experimented. He expressed some doubt as to whether the effect of hydrogen on the brittleness and tensile strength of steel was as yet fully understood.

Professor B. P. Haigh expressed a little regret that the introduction of lagging between the steel and the vessel had cut short the contents of the reaction investigation into hydrogen embrittlement. He was inclined to question whether the phenomenon encountered was really hydrogen embrittlement. He thought it might possibly be a case of "creep" complicated by the very steep temperature gradient through the walls of the vessel and the distribution of stress in them. These two conditions would, on the assumption that the fracture of the vessel was caused by creep, give the results observed namely cracking extending from the inside outwards. Nevertheless he had to admit that in one case in which the crack had reached the periphery of the cylinder it was impossible to explain the action entirely on the basis of creep and that it must have been caused or completed by chemical attack in the absence of stress.



Dr. James Burns discussed the difference of the effects produced by hydrogen and sulphur in high-pressure reaction vessels. Two such vessels, he said, had been examined after 20,000 hours' use. In one, exposed to hydrogen attack, the carbon of the steel had been completely removed on the inside surface and there was a gradation to normal steel towards the outer surface. In the other vessel, exposed to hydrogen sulphide, the sulphur was found to have had a protective effect. In small tubes sulphur corrosion might be very serious but in large reaction vessels its effect was protective.

Mr. Hamilton Martin described certain steps which had been taken on the Continent to overcome the metallurgical difficulties encountered in high-temperature, high-pressure converting plants. A relatively low chrome-aluminium alloy steel had been developed for the purpose. This alloy, he said, contained less than 0·05 per cent. of sulphur and was of a ferrite-pearlitic structure. It was heat resisting and non-scaling to a high degree and showed great strength and low creep characteristics at elevated temperatures. The resistance to attack by sulphur and compressed hydrogen was noticeably high. In use a dense highly adherent layer of aluminium oxide formed on the exposed surface of the steel and acted as a protective coating. About twenty-five hydrogenation converters and other vessels exposed to high temperatures and pressures had been made of this alloy. He attributed the satisfactory behaviour of the alloy to the presence in it of aluminium and to the absence of nickel. The steel was available in various grades to resist temperatures ranging from 600 deg. Cent. to 1200 deg. Cent. Mr. Martin also mentioned a process whereby the surface of a vessel made of any kind of steel could be "alumetised" by which a layer of protective aluminium oxide could be formed on the surface.

Lt.-Col. E. Kitson Clark asked for an explanation of the manner in which creep could occur on the inside of a thick-walled tube. He had difficulty, he said, in understanding in what way the metal found room to creep. Professor Haigh, responding to an invitation to explain this point, drew a diagram on the blackboard on the lines of the figure given above. If, he said, the curve A B represented the distribution of stress in a thick-walled cylinder, according to Lamé's theory, when the metal was cold, then when it was heated the stress distribution would alter in some such way as that represented by the curve C D. The areas under the two curves would be equal if the pressure inside the cylinder remained constant. If E F were the limiting creep stress for the metal then the area E J D would represent a non-effective contribution to the support of the load and an equal area J G H C would have to be added on to the lower portion of the diagram to compensate for it. The stress distribution curve would then be represented by E G H. Under the increased stress represented by the added area J G H C the metal on the outside of the cylinder would expand and by so doing would provide the room required for the metal on the inside to creep.

Mr. W. B. Shannon, referring to the difficulty encountered in the seizing of the nuts on the bolts of the end covers for the reaction vessels, asked whether any attempt had been made to overcome this trouble by using ground threads. He noted that it had been found difficult to weld, by the oxy-acetylene process, steel tubing or other parts that had been in contact with hydrogen under pressure for a relatively short time. Electric welding, he suggested, might have been tried as a means of surmounting this trouble.

Dr. A. P. Thurston asked whether the coating or impregnation of the exposed surface of the steel vessels with copper would be of any service as a protection against hydrogen attack.

Mr. R. W. Allen suggested that the resistance of the reaction vessels to hydrogen embrittlement might have been increased if they had been heat treated and tempered in oil.

Mr. Taylor replied briefly to the discussion. Dealing with pressure gauge failures, he revealed the fact that at the Greenwich station the tubes of such gauges were made of chrome-molybdenum alloy steel and that the trouble had been traced to the presence of minute cracks in the tubes. Replying to Dr. Burns he agreed that a sulphur scale would have a protective effect but if the temperature were raised and lowered repeatedly the scale would crack and allow the hydrogen to penetrate to the steel beneath it. Referring to Mr. Martin's remarks regarding the use of chrome-aluminium steels he said that they were a little afraid of such steels as aluminium by itself had been found to corrode badly when used inside the reaction vessels. He agreed with Mr. Shannon that ground threads would probably reduce the tendency of the nuts to seize on the end cover bolts and had to admit that some of the threads actually used were not very good. Generally however the tendency to seize could be overcome by coating the threads with graphite either dry or in paste form. Replying to Dr. Thurston he said that no experiments had been carried out to study the protection that might be afforded by coating the exposed steel surfaces with copper. So far they had preferred to obtain the desired result by using alloy steels but they were about to investigate a particular coating process for which much was claimed. He doubted whether heat treatment and oil tempering would, as Mr. Allen had suggested, prolong the life of the vessels by any considerable amount but he admitted that the point had not been investigated.

Mr. Charles Day, the President, in bringing the meeting to a close, commented upon the fact that at one time the effect of nitrogen on steel had been the cause of very serious trouble but that with the development of the nitriding process it had been turned to advantage as a means of obtaining great surface hardness. He wondered whether a similar result would one day be recorded for hydrogen and whether what was now a curse would be turned into a blessing.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

GAS FOR INTERNAL COMBUSTION LOCOMOTIVES.

SIR,—The letter of Mr. William P. Durtnall in your issue dated September 28th, introduces a railway proposition of perhaps special interest in respect of shunting locomotives of the type and power used for quay and yard movements at a seaport, *i.e.*, an all-wheels-coupled engine of about 20,000 lb. starting tractive effort, either 0–6–0 or 0–8–0.

With such engines, using steam as motive power, there are always stand-by losses due to the fluctuations of work. Two men are also required on the engine. It would appear that there is a field for such a locomotive using producer gas, the prime mover being either coupled to the wheels electrically or through a robust system of gearing. Stand-by losses would be small and one man could handle the engine, the coal feed to the producer being semi-automatic.

As a matter of interest, it may be stated that Nigeria produces all her own coal, both the mines and the railway being operated by Government. A recent analysis of Nigerian coal is as hereunder:

Ultimate Analysis (Dry Ash Free).

Carbon	80·6 per cent.
Hydrogen	6·1 ,, ,,
Nitrogen	1·8 ,, ,,
Sulphur	1·0 ,, ,,
Difference	10·5 ,, ,,
Calorific value	14,550 B.Th.U.
"As received" value	12,018 ,,

How would Mr. Durtnall view the proposition of a producer gas shunting locomotive for a Nigerian seaport?

G. V. O. BULKELLY,
General Manager, Nigerian Railway.

Ebute Metta, November 2nd.

High Rupturing Capacity Fuses.

No. V.

(*Concluded from page 484, November 16th.*)

ALTHOUGH at the moment few electrical manufacturers are in a position to supply high rupturing 132-kV fuses, there are indications that new fuses suitable for this voltage will be available in the near future. Ferguson, Pailin, Ltd., report, for instance, that a thermal gas cut-out is showing promising results. Short-circuiting rupturing capacity tests have been made at pressures as low as 440 volts and as high as 132 kV, but development work is still proceeding and details of design cannot unfortunately be included in this series of articles. The new fuse is intended for protecting low and medium pressure circuits, as well as the highest voltage circuits. High rupturing fusible cut-outs are also being evolved for medium and low voltage work. The British Thomson-Houston Company has produced and tested a new 132-kV oil blast fuse, which we hope to describe in an early issue.

At present the liquid or chemical fuse, commonly known as the tetrachloride fuse, as illustrated in Fig. 3 of the first article, is the type most commonly employed in this country on the highest voltage circuits. Tests on the grid lines with a specially designed Allen West liquid fuse were described in our issue of October 14th, 1932. The conclusions drawn from these tests were that under certain conditions these fuses can provide an inexpensive means of tapping high-tension lines at points where the cost of installing high rupturing capacity circuit breakers is prohibitive. Another firm that supplies liquid spring-operated fuses of the tetrachloride type for voltages ranging from 6·6 kV to 132 kV and for currents ratings of 1–400 ampères, is Switchgear and Equipment, Ltd., of Banbury, Oxon. The general principle corresponds with that described, but the makers claim to have introduced certain improvements, such as a new moisture proof container having exceptional strength and heat-resisting properties, a large explosion chamber with heat-resisting walls, a new pattern liquid director combined with an anti-vibration device, and an improved method of mounting the fuse element which is claimed to permit of finer grading of the fuse and increased speed of break. All the external and internal metal parts are nickel plated to make them resist corrosion.

FIG. 49—CARTRIDGE FUSE TROUGH ASSEMBLY

With the maker's fuse isolator shown in Fig. 47, which is applicable to 11 kV and 33 kV systems, the fuses are well away from the insulation and earthed metal work. There is no risk of the insulation being damaged when the fuse clears a heavy fault. By reason of the clear gap introduced by the collapse of the spring, a fuse that has blown can readily be detected at the ground level. The fuses have an estimated rupturing capacity of 150,000 kVA at 11 kV and 250,000 kVA at 33 kV. With the aid of a light 16ft. 6in. operating pole the fuses are easily removed and replaced from the ground. The bell guide, to be seen in Figs. 47 and 48, readily enables the fuse to be properly located under the worst conditions. The action of inserting the fuse in the contacts or in the isolating position, shown on the right of Fig. 48, automatically unlocks the connection between the fuse and pole head. Similarly, the action of removing the fuse from the contacts or from the isolating position locks the fuse in the pole head. The three illustrations, Fig. 47, show a fuse being replaced. In the first picture on the left the fuse is approaching the bell guide; in the centre it is being locked in position; and in the third picture the operating pole is withdrawn.

The illustration, Fig. 48, shows how a fuse may be moved from its normal operating position into an isolating position, which can be arranged for when required. On the left the operating rod is being locked to the fuse; in the centre, the fuse has been lowered to the insolating position; and on the right the fuse has been locked in that position and the operating rod has been withdrawn.

Semi-enclosed fuses for ordinary duty and cartridge fuses for heavy duty on A.C. and D.C. circuits, working at pressures up to 660 volts and for a maximum current in the former case of 600 ampères and 700 ampères in the latter, are made by A. Reyrolle and Co., Ltd., of Hebburn-on-Tyne. The former must not, however, be confused with really high rupturing capacity fuses, for, as an approximate general rule, they can only be used on three-phase systems on which the available short circuit kVA is less than 5000, but a comparison of the two types is not without interest. Apart from the fact that cartridge fuses are suitable for clearing much heavier short circuits than the alternative pattern, the current carried continuously by them may be closer to the fusing current than is permissible with the semi-enclosed type. In other words, the fusing factor or the relation between the rated current and minimum fusing current is lowest in the case of the cartridge fuse, which also has more reliable and accurate characteristics. Another factor governing the choice is the permissible overload and its duration—the overload the fuse must carry for a stated time. Broadly speaking, Reyrolle semi-enclosed fuses cannot be satisfactorily used if the rated current exceeds one-half of the minimum fusing current requisite; in other words, the lowest fusible factor obtainable with semi-enclosed fuses is about 2. Cartridge fuses, on the other hand, may be employed for continuous working currents not exceeding 0·7 of the minimum fusing currents, the minimum fusing factor being $\frac{1}{0{\cdot}7}=1{\cdot}4$. The fusing elements for currents below 100 ampères are necessarily composed of fine wire, and up to this current value it is the maker's standard practice to use a fusing factor of 1·7 for cartridge fuses. By using suitable wiring in fusible elements of either type, it is, of course, possible to obtain higher fusing factors than those stated, the maximum fusing factor that can be obtained at any current rating being restricted by the amount of wire that can be safely accommodated. The bases of fuse assemblies originally supplied with semi-enclosed fuses for ordinary duty can generally be used if necessary at a later date for heavy duty cartridge fuses, and fuse holders of certain sizes may be used without alteration to accommodate either semi-enclosed or cartridge fuses of certain ratings.

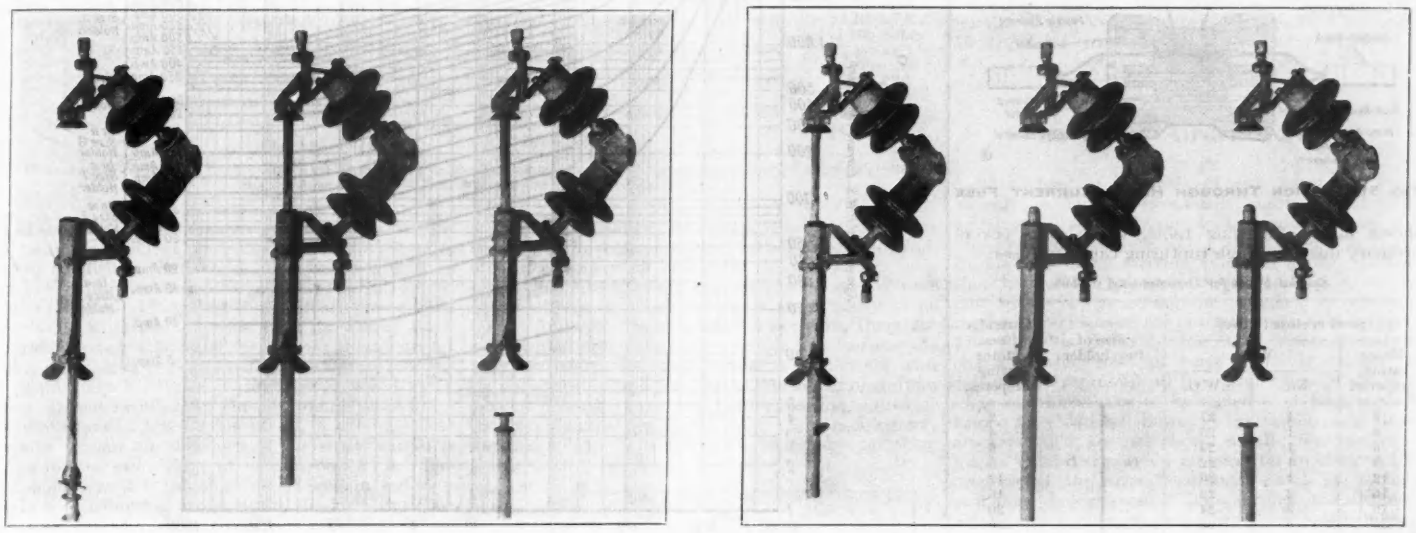
Cartridge fuses should always be employed when discriminative operation or grading is required. Satisfactory discrimination can be secured between Reyrolle cartridge fuses having current ratings in the ratio of 3 to 1. A 100-ampère cartridge, for example, used in series with a 300-ampère unit will always clear a fault satisfactorily before the larger fuse. If the ratio be less than 3 to 1, successful grading, though still obtainable, is not so certain, except when the available short-circuit current is comparatively small. On account of their accuracy of rating and high short-circuit capacity, Reyrolle cartridge fuses with an appropriate fusing factor are claimed to be suitable for the protection of direct started motors.

Circuits on which the load does not fluctuate much above the normal value require the fuses to operate as soon as possible after the rated current is exceeded continuously, and fuses of the lowest fusing factor possible for the type chosen should be selected from the table below, which covers ordinary duty and high rupturing capacity fuses.

Fuses for Steady Loads.

	Semi-enclosed fuses.			Size of fuse holder.	Cartridge fuses	
	Normal rating, ampères.	Wires. No.	Wires. S.W.G.		Normal rating, ampères.	
Fusing factor 2·0	2	1	37	D	5	Fusing factor 1·7.
	3	1	34		10	
	5	1	30		15	
	8	1	26		20	
	10	1	24		30	
	15	1	22	D		
	20	2	23		40*	
	30	2	22	E	50	
	40	3	22		60	
	50	4	22			
	60	6	22	F	80	
					100	
	80	6	21			
	100	6	20	E	G 150	
					200	
	150	6	18	F		
					250	
	200	9	18	G	H 300	Fusing factor 1·4.
					350	
	250	12	18	H	400	
	300	15	18			
					450	
	350	19	18		500	
	400	23	18	J	550	
	500	4	7/18		J 600	
	600	5	7/18		650	
					700	
	Tinned copper wire should be used					

It is permissible for these fuses to have as part of their load direct started motors having a full load current not exceeding one-third of the fuse rating, or they may be used for individual motors with starting



FIGS. 47 AND 48—FUSE ISOLATORS WITH E.H.T. TETRACHLORIDE FUSE

equipments up to their full current rating. Circuits containing individual direct started motors must have fuses capable of withstanding the heavy starting currents for short periods, and the fuses must therefore have a higher fusing factor than those in circuits of the first-mentioned kind. If the normal

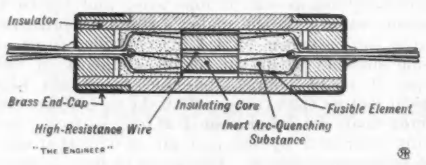


FIG. 50—SECTION THROUGH 100-AMPERE FUSE

full-load current of a motor is greater than 60 ampères, it is not possible to accommodate the necessary fuse wire in the standard cartridge without impairing the short-circuit capacity, and it then becomes necessary to use larger cartridges and holders, as

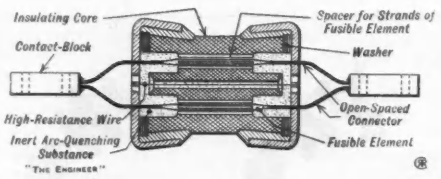


FIG. 51—SECTION THROUGH HEAVY CURRENT FUSE

shown in the following table, which also covers ordinary duty and high rupturing capacity fuses.

Special Fuses for Direct-started Motors.

Semi-enclosed fuses.			Size of fuse holder.		Cartridge fuses, Motor rating, ampères.
Motor rating, ampères.	Wires. No.	Wires. S.W.G.			
2	1	27	D	D	2
4	1	25			4
6	1	23			6
8	1	22			8
12	1	20			12
16	2	22			16
20	5	24			20
30	4	20			30
40	5	20	E	E	40
50	7	20			50
60	9	20			60
80	9	18	G	H	80
100	12	18	H		100
150	19	18		J	150
200	23	18	J		200
250	4	7/18			250

Tinned copper wire should be used for semi-enclosed fuses.

The fuse ratings given in this table and the one preceding it correspond to the normal full-load currents of the circuits in which the fuses are to be used, and do not refer to the fusing currents. Based on 80 per cent. efficiency and 0·8 power factor, the following rough formula may be used to determine the rating in ampères of fuses suitable for a three-phase motor :—

Fuse rating = Full-load motor current.
= Horse-power × 650/voltage.

A 25 horse-power, 440-volt, three-phase motor, for example, has a full-load current of approximately $25 \times 650/440 = 37$ ampères, and 40-ampère fuses (the next larger rating) should be used. If the motor has starting equipment the fuse should be selected from the first table, the fuse consisting in the case of the semi-enclosed type of three strands of No. 22 S.W.G. tinned copper and a fuse marked * in the case of the cartridge type. But if the motor is direct-started, use should be made of the second table, which gives five strands of No. 20 S.W.G. tinned copper wire for a semi-enclosed fuse.

According to requirements, these Reyrolle fuses are mounted in various ways. The fuse holders have self-aligning contacts, which engage with fixed contacts arranged for back or front connection. The contacts can be fitted in insulating troughs as complete units in all sizes except size J, or loose for mounting on existing panels, or mounted on a slate panel in all sizes. Wherever possible, the makers recommend that the complete assembly in a moulded insulating trough—Fig. 49—should be used, as it has been designed to prevent accidental contact with live parts.

All Reyrolle cartridge fuses are constructed on the same principle, but the end connections of cartridges for normal currents up to 100 ampères inclusive—see Fig. 50—are made in a slightly different way from those for the larger sizes (Fig. 51). The fusible element consists of a number of strands of pure silver wire and one strand of relatively high-resistance wire, each wire being threaded through a separate hole in spacers fitted in a strong insulating core. The ends of the fusible elements are securely connected to copper tails, and the space near the junctions is filled with an inert arc-quenching substance. Tinned brass end caps are fixed to the core, and the copper tails extend through the caps, and are soldered to them. In cartridges for currents up to 100 ampères the copper tails are connected directly to the copper blocks on the fuse holders, whilst in the larger cartridge the tails are soldered to substantial independent copper blocks which afford a means of attaching the cartridges to the contacts on the fuse holders.

The restriction of the formation of arcs under short-circuit conditions, and the provision of adequate means of dissipating the energy produced, are the chief reasons for subdividing the fuse element and for accommodating each sub-element in a separate de-ionising chamber. Silver wire is used for the fuse element because it is believed to be the most suitable wire for the purpose. As it does not oxidise or deteriorate when carrying current practically up to the fusing value, it enables a low fusing factor to be obtained, and it permits of a smaller section wire to be employed as compared with other fusible elements, such as those composed of tin. Thus, when a silver wire fuse element blows on the occurrence of a fault, there is less metal to be volatilised than usual, less vapour to be de-ionised, and less arc energy is produced.

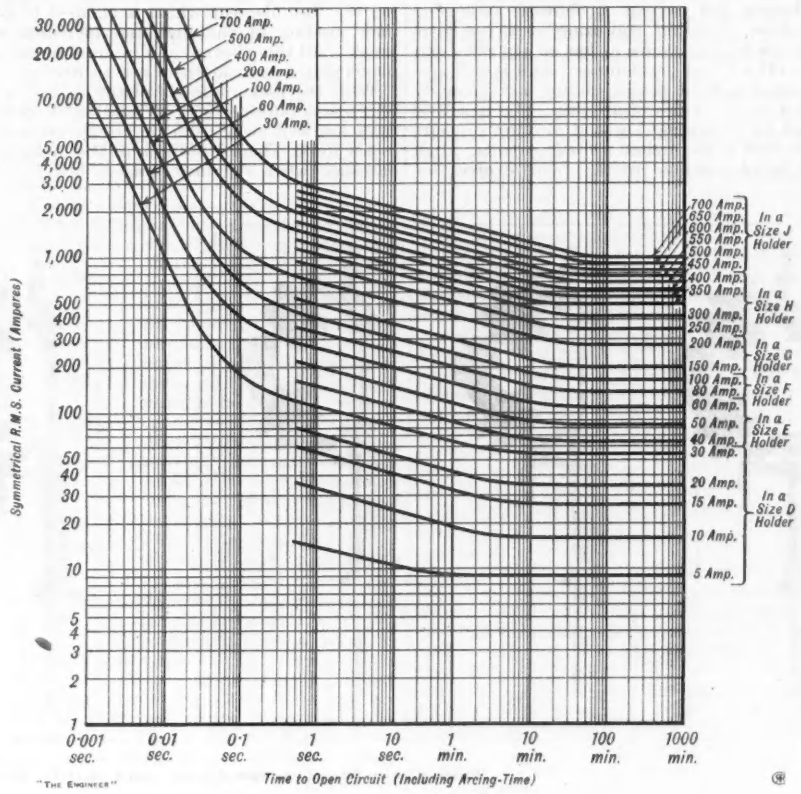


FIG. 54—TIME-²CURRENT CURVES

According to the magnitude of the fault, the silver fusible elements are melted or are volatilised. The alternative path through the high-resistance wire prevents the application of the restriking transient or recovery voltage to the vaporised silver, and provides a small time delay during which de-ionisation of the vapour takes place as a result of the turbulence and pressure existing within the cartridge. The high-resistance wire, which is conveniently situated in the centre of the fuse core, finally clears the fault. The results given in the next table are typical of many hundreds obtained from short-circuit tests on these cartridge fuses of all ratings under varying conditions of voltage and fault kVA at the Reyrolle short-circuit testing station.

The figures given in column 9, the makers point out, justify the high short-circuit capacity ratings associated with these fuses, and show that tests have proved that they have an adequate factor of safety. The fuses are at least suitable for use on any system on which the short circuit kVA available as calculated by ordinary methods is in the neighbourhood of 25,000 kVA at 660 volts, and in some cases the rating may be considerably increased above that value.

The fuse under test was connected in each case across the low-voltage winding of a transformer said to be capable of producing on a dead short

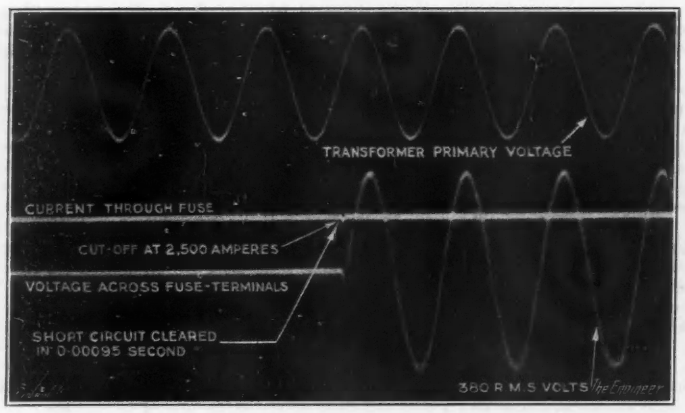


FIG. 52—SHORT CIRCUIT TEST ON 30-AMPERE CARTRIDGE FUSE

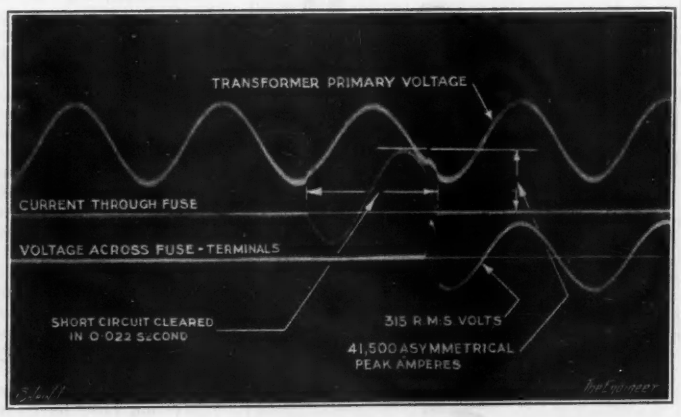


FIG. 53—SHORT CIRCUIT TEST ON 700-AMPERE CARTRIDGE FUSE

circuit between its terminals an asymmetrical short circuit current practically 2·9 times greater than the maximum recorded in the table. On the primary side the transformer was connected to the test alternator with a capacity sufficient to ensure that the heavy short circuit current caused very little voltage drop and the recovery voltage was virtually 100 per cent. of the initial voltage. The magnitude of the short circuit kVA was controlled by inserting resistance and reactance in the transformer primary circuit, giving a power factor of 0·1 lagging, which, together with the rapid rate of rise of restriking voltage that occurs with the testing equipment used imposed very much more severe conditions than those that are met with in service. After the test alternator had been excited to the required voltage the short circuit was applied by closing a switch in series with the fuse. Each cartridge tested was wired for its maximum current rating and therefore contained the maximum amount of fusible metal. When a cartridge is wired for a lower current rating than the maximum, and consequently contains less fusible metal, it produces less metallic vapour on blowing and the stress within it is less for the same value of short circuit kVA. The test conditions are therefore eased, and in order to produce the limiting stress again the kVA must be increased. Under these conditions the kVA values for the cartridges given in the table may be increased. A size H cartridge, for example, can be wired for 250, 300, 350, and 400 ampères. The cartridge tested was wired for 400 ampères, and since at all the other three ratings it would contain less fuse wire, its performance would be better than that recorded.

As the figures in column 8 of the table indicate, all the fuses with the exception of those rated at 500 and 700 ampères opened the circuit in less than one-quarter cycle, or 0·00625 second, and consequently, as column 7 shows, cut off the current at a value below that of the maximum peak current available. The value of the actual peak current available in the first half cycle depends upon the degree of asymmetry of the current wave and lies between the symmetrical peak current as a minimum and the maximum asymmetrical peak current as a maximum, the latter being taken as equal to 1·8 times the symmetrical peak value. To arrive at the values given in columns 4, 5, 6 of the table a copper link was inserted in the test circuit in place of the fuse, and the value of the current in the first cycle after the application of the voltage (column 3) was used to determine the values of the symmetrical peak current available, symmetrical R.M.S. current available, and the maximum asymmetrical peak current available.

The values given in column 9 of kVA at a definite voltage available in the test circuit are based on symmetrical short circuit values, because this enables them to be directly compared with kVA values available in any network calculated on well-known lines by taking into account the impedance and voltage of the circuit in which the fuses are actually to be used. Amongst the test figures, however, there are some which prove the ability of the fuse to clear the fault satisfactorily both under symmetrical and asymmetrical conditions, and in which the maximum current carried by the fuse before blowing is greater than the symmetrical peak value. The oscillogram, Fig. 52, relates to a test on a 30-ampère cartridge fuse with 57,500 symmetrical peak ampères available, and Fig. 53 a test on a 700-ampère cartridge fuse with 35,200 symmetrical peak ampères available.

1.	2.	3.	4.	5.	6.	7.	8.	9.
Size of fuse holder.	Rating of cartridge (ampères).	Single-phase test voltage (volts).	Symmetrical peak current available (ampères).	Symmetrical R.M.S. current available (ampères).	Maximum asymmetrical peak current available (ampères).	Maximum current carried by the fuse before blowing (ampères).	Time taken to clear the short circuit (seconds).	*Equivalent three-phase kVA available at the equivalent three-phase line voltage.
D	30	380	57,500	40,600	103,500	2,500	0·00095	46,500 kVA at 660 volts
E	60	380	42,300	29,900	76,000	7,500	0·00125	34,100 kVA at 660 volts
F	100	315	35,200	24,900	63,000	10,000	0·00176	23,500 kVA at 550 volts
G	200	380	42,300	29,900	76,000	25,000	0·00615	34,100 kVA at 660 volts
H	400	315	35,200	24,900	63,000	33,800	0·00567	23,500 kVA at 550 volts
J	500	350	39,000	27,600	70,000	50,000	0·01000	29,900 kVA at 600 volts
J	700	315	35,200	24,900	63,000	41,500	0·02200	23,500 kVA at 550 volts

* The values of equivalent three-phase kVA available have been calculated from three times the product of the single-phase test voltage and the R.M.S. symmetrical current available.

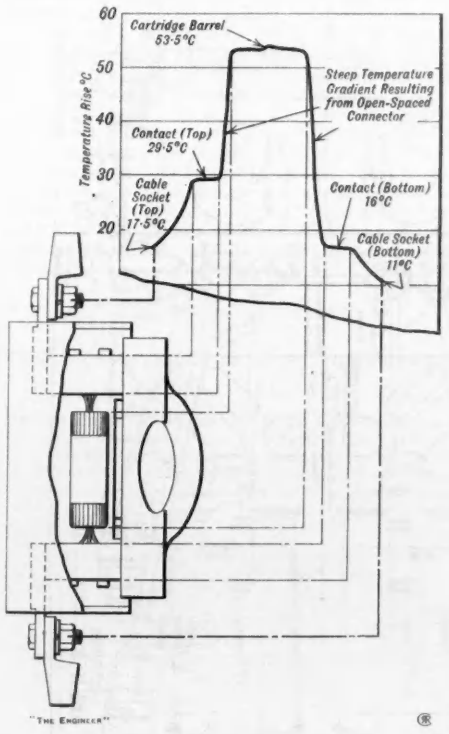


FIG. 55—TEMPERATURE DIAGRAM OF 30-AMPERE CARTRIDGE FUSE

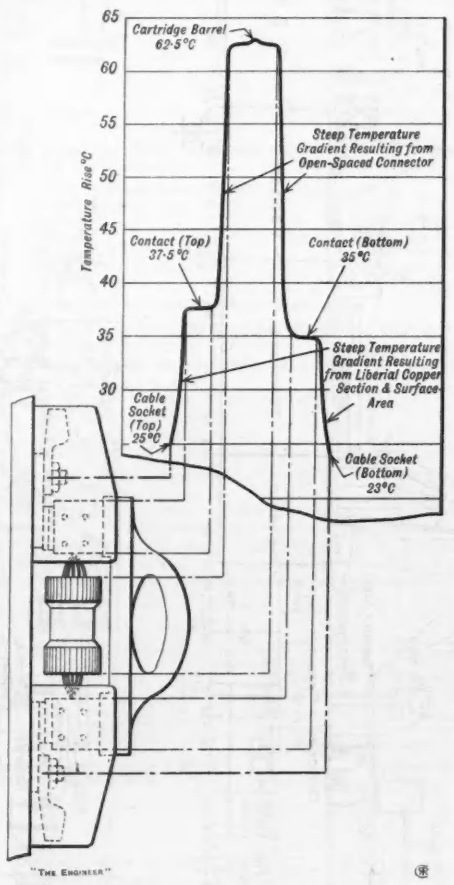


FIG. 56—TEMPERATURE DIAGRAM OF 700-AMPERE FUSE

The chart, Fig. 54, based on the tests described and others, shows the operating characteristics of all fuses of standard ratings. The operating time includes the arcing time in addition to the fusing time, and thus give the total interval between the time when the fault occurs and the final clearing of the circuit. Although arcing time is not a large proportion of the total times longer than 0·1 second, it becomes important in other cases. To keep the scales open at small values, the curves are plotted to logarithmic scales on both axes.

Notwithstanding the low fusing factor obtainable with these fuses, they remain cool even over long periods at full load. Overheating is said to have been entirely eliminated, particularly at the contacts and cable sockets, where its effect would be to cause rapid deterioration. The low fusing factor combined with exceptionally cool working is the direct result of the open-spaced connector, which, in association with the liberal contact sections of the other parts of the cartridge, gives exceptionally good heat dissipation. Results of tests on 30 and 700-ampère cartridge fuses with different fuse assemblies are shown graphically in Figs. 55 and 56 respectively. Standard cartridges were mounted in their normal working position, and the tests were extended over a period of 100 hours in an ambient temperature of approximately 15 deg. Cent. Throughout the tests the fuses carried their rated currents and the maximum temperatures recorded after two hours (which, we believe, is an exceptionally short period for a heavy duty fuse) are indicated in the illustrations. On the 700-ampère fuse the maximum temperature rise at the hottest part was 62·5 deg. Cent., the rise at the top and bottom contacts being 37·5 deg. and 35 deg. Cent. respectively. Corresponding temperature rises for the 30-ampère fuse were 53·5 deg., 29·5 deg., and 16 deg. Cent. respectively.

The Paris Aircraft Show.

BEING held at intervals of two years, the Paris aircraft exhibitions necessarily mark considerable advances in a rapidly developing industry, and the Show which was opened in the Grand Palais on Friday last offers striking evidence of the changes that have taken place in design and construction, particularly by revealing the influence of national methods and ideas on the perfection of machine types. The Show is probably the most international in character that has yet been held. It cannot be expected to represent all the latest types of aircraft, some of which have to be tested over long periods before they can be shown to the public, and there are some that are not shown at all; but the aeroplanes exhibited provide an occasion to observe the progress of the aircraft industry and to foresee probable developments. So far as the French industry is concerned there has been, until of late years, a lack of co-ordination with a dispersal of effort resulting in the creation of a considerable number of types, so that while the country has probably the largest number of military aeroplanes, and ranks high in civil aircraft, the machines are heterogeneous in character, and the bulk of them are already out of date. Since the creation of the French Air Ministry the situation has changed, and reorganisation of the industry, and selection of types of machines to allow of economical construction on a suitably large scale, give promise of French aviation recovering its old reputation. Some of the selected types of aircraft are on view in the Grand Palais.

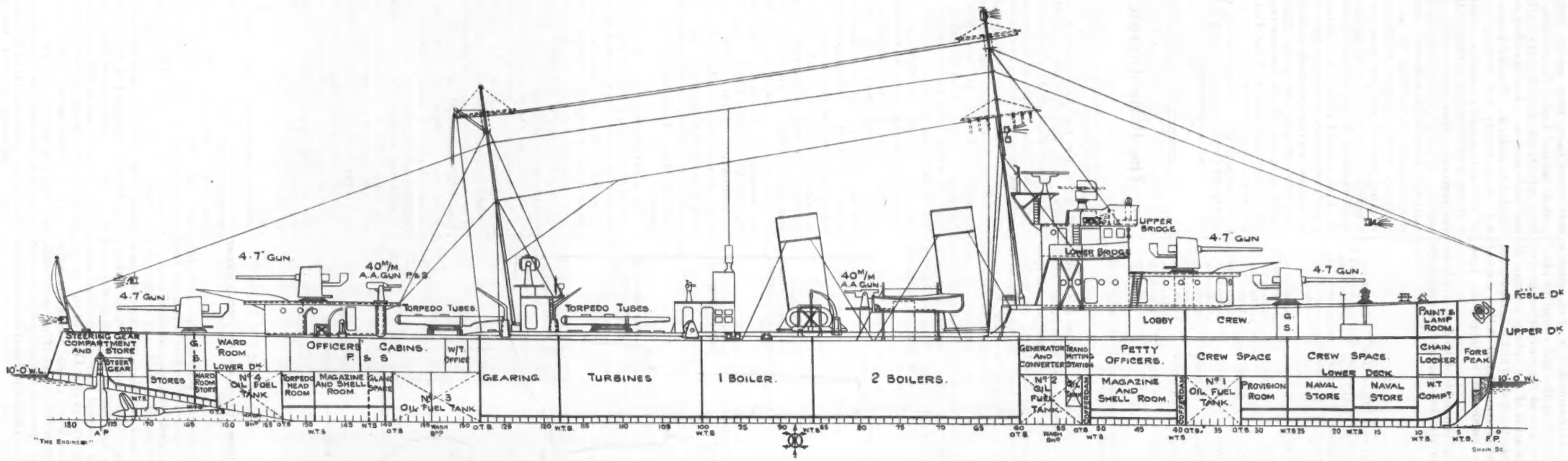
The short space of two years has seen the elimination of wood from aircraft construction and a striking advance in metal alloys, as well as in their mechanical utilisation. The new industry is responsible for a phase of metallurgical progress that would not have been possible without the intensive research and experimental work carried out by metallurgists and engineers all over the world. The construction of an aeroplane opens up a wide field for the exercise of ingenuity in the choice of metal sections and in assemblages to provide the maximum mechanical resistance for the lowest possible weight, and there is no reason for supposing that progress in this direction will be arrested for years to come. In aircraft design the machines exhibited do not indicate any notable departure from tendencies that have guided aircraft designers in the recent past. The necessity of reducing air resistance to a minimum has led to the suppression of external struts and stays, except in a few types of machines where they are employed in a form that offers little resistance, and the general tendency is to build the plane into the fuselage, which favours monoplane construction, with occasionally a short under plane to carry engines in the case of heavy fighting machines. Such types are observable in the French civil and military aeroplanes which have much in common. The Amiot commercial machine, the Olivier seaplane for the Mediterranean services, and the Breguet passenger and fighting aeroplanes are examples of types accepted under the new organisation. The Amiot has a hemispherical look-out above the fore end of the fuselage similar to the machine gun turrets on some military aircraft. There is no settled arrangement of engines, except in the case of the three-engined machines, with one in front of the fuselage and two on the planes. The Olivier seaplane has four engines in two groups fore and aft well above the plane. The engines develop 1400 horse-power, and the total weight of the machine is 9 tons with a load of 2½ tons.

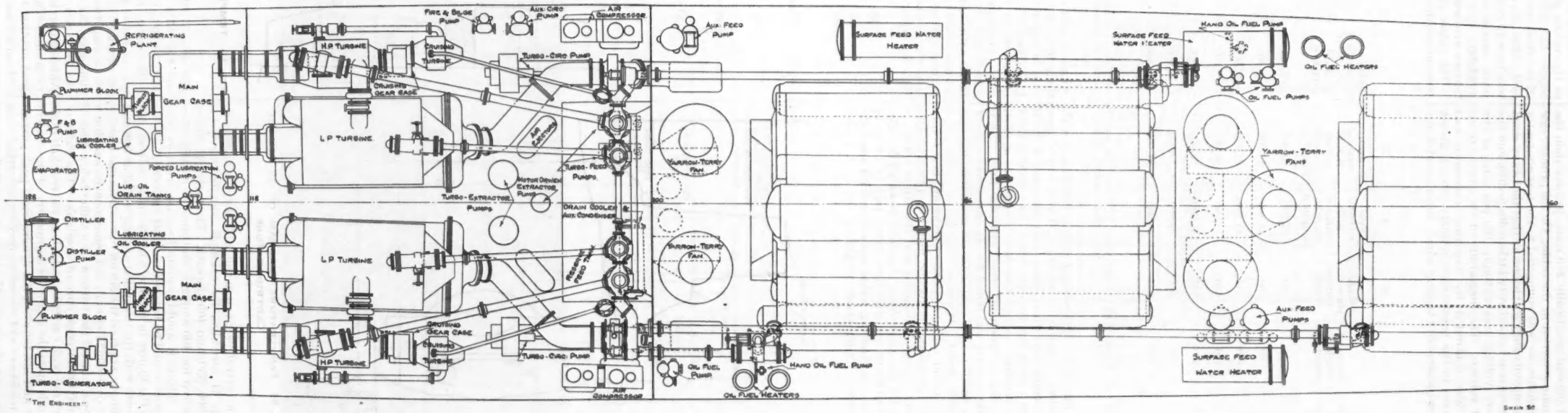
The construction of private aeroplanes is regarded in France as an essential feature of air defence, and upon this depends the successful operation of the scheme to promote private flying throughout the country. There are numerous flying clubs that receive

PORTUGUESE DESTROYER—LONGITUDINAL SECTION AND PLAN OF ENGINE AND BOILER ROOMS

YARROW AND CO., LTD., SCOTSTOUN, BUILDERS AND ENGINEERS

(For description see opposite page.)





State subventions which are declared to be wholly insufficient to give the desired impetus to the movement. The machines and their maintenance cost far too much. Nevertheless, private flying is fairly active in view of the formation of military pilots, but its progress can only be helped by the State, for aircraft constructors can hardly bring down the cost of machines that cannot be produced to type in sufficient numbers. There are two constructors at the Exhibition who are now specialising in light aeroplanes with engines of about 140 horse-power, and Farman also continues to build them, so that there is practical evidence of the increased activity of the Federation of Flying Clubs which held a congress during the exhibition. The Hanriot machines are of two types, one for observation, with variable-pitch propeller, and another with fixed propeller for private flying.

In the German section the aeroplanes shown cannot be regarded as having been constructed for anything but commercial purposes. Some of the machines are replicas of those in service, and their interest lies perhaps in a simplicity of design and equipment and more particularly in the fitting of heavy-oil engines. This problem of heavy-oil fuels for aeroplanes is of special importance to the French. The Air Ministry has offered a prize of 10 million francs for the first heavy-oil engine of French construction which will beat the existing circuit record of 10,000 kiloms. at an average speed of slightly below 150 kiloms. an hour. The offer holds good until the end of 1936. If the engine is built under a foreign licence the prize will be reduced to 5 million francs. The Soviet participation is characterised by a spirit of progressiveness which is observable more in performance than in actual technical advance. Russia has her own special problems in providing for lack of transport facilities over a vast country by a development of aviation on a scale unsurpassed elsewhere, and this tends to lead Russian aircraft engineers away from the practice of other countries, though there is no evidence yet of Soviet development on a colossal scale having contributed to actual progress. Models are shown of types of monoplanes with from one to seven engines, said to be constructed on mass-production lines. The details of aircraft construction show good work, and the documentary exhibit reveals that Russia is hardly behind other countries in scientific and testing equipment. Russian aircraft developments are worth watching. There are exhibits from nearly all countries, including the Italian record-breaking seaplane, a Czechoslovakian monoplane with two guns in the wings and two machine guns in the cockpit, while the British participation is particularly good, alike in aircraft and engines. Each country has its definite characteristics, and the British machines stand out for their neat engineering and practical construction.

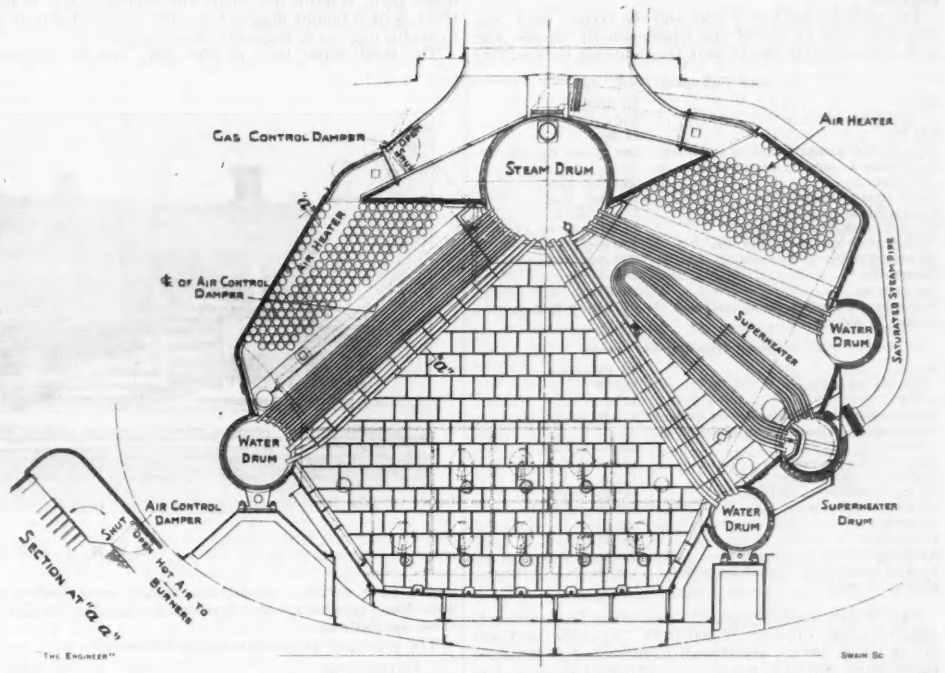
There is more to be learnt about the progress of aviation from the sections devoted to the scientific and technical aspects of the industry than from an inspection of the machines themselves. They imply refinements in aircraft design rather than departures from present recognised principles. Further developments may turn in the direction of a more general use of variable-pitch propellers and the introduction of successful heavy-oil aircraft engines.

Trial Performances of a Destroyer.*

By SIR HAROLD YARROW.

RECENT improvements in the design and construction of merchant vessels, as regards both the most suitable form of hull and developments in marine engineering, such as the introduction of high-pressure steam and the extended use of water-tube boilers, have formed the subject of many papers. On the other hand, little has been written concerning naval vessels, despite the concurrent application of new ideas over the same period. The problems to be solved for the two services are, of course, widely variant, but, nevertheless, of equal importance to a country dependent on sea connections. It was thought, therefore, that a short paper embodying a description and trial performances of a modern torpedo-boat destroyer might be of interest to the Institution and promote a useful discussion.

The vessel selected for this paper is of the design adopted for the new flotilla ordered by the Portuguese Government from Yarrow and Co., Ltd., in 1931. The original order was for four destroyers, but was subsequently increased to seven when two were transferred to the Colombian Government at the beginning of the year. As in the case of previous contracts with Yarrow and Co., Ltd., the Portuguese Government was anxious to undertake the building of some of the vessels in Lisbon. Consequently, the first two vessels were built entirely on the Clyde, the other hulls were built in Lisbon by the Sociedade de Construcoes e Reparacoes Navaes, Ltda., acting as sub-contractors to Yarrow and Co., Ltd., who supplied the whole of the hull material and the machinery completed ready to install on board. The two Clyde-built vessels, "Vouga" and "Lima," and two of the five Portuguese-built vessels, have already been completed and handed over.



BOILER FOR PORTUGUESE DESTROYER

All seven vessels are practically similar and the principal designed particulars are :—

Length between perpendiculars	307ft.
Length overall	323ft.
Beam	31ft. 2in.
Depth	18ft. 9in.
Displacement, fully loaded	1620 tons
Speed at trial displacement	36 knots
Radius of action at 15 knots	5400 knots

The armament consists of the following, viz.:—

Four 4·7in. 50-calibre guns with 140 rounds of ammunition per gun ;
Three 40 mm. anti-aircraft guns, with 1500 rounds of ammunition per gun ;
Two quadruple 21in. torpedo tubes ;
Eight 21in. torpedoes ;
Depth charges and throwers ;
Arrangements for carrying and laying mines.

There is a complete system of fire control for both guns and torpedo tubes.

The guns, ammunition and fire control apparatus were supplied by Vickers-Armstrongs and the torpedo tubes and torpedoes by the Whitehead Torpedo Co. A complete equipment for submarine signalling, echo sounding, gyro-compass control, direction finding and wireless telegraphy is provided in accordance with up-to-date modern practice.

The design which embodies the latest ideas for an ocean-going destroyer is shown on the opposite page, where the machinery and boiler-rooms are also shown. A somewhat exceptional feature of the engine-room is the transverse bulkhead between the main turbines and gearing. It subdivides efficiently the most vital parts of the vessel, and at the same time leaves ample space for working the engines and gives good access to all parts. The gearing compartment also is cool and free from vapour, and therefore suitable for the inclusion of the electric installation.

The main engines comprise a high-pressure impulse and low-pressure Parsons turbine on each shaft, the casing of the former being cast steel and of the latter cast iron. A cruising turbine, capable of propelling the vessel at speeds up to 15 knots, is coupled through a clutch to each high-pressure turbine. The low-pressure turbines are of the double-flow type, *i.e.*, the steam enters at the centre of the casing and flows axially fore and aft before passing to the underslung condensers, which are of the Weir regenerative type. Each turbine has a centre diaphragm and only one half is used for cruising, the other half running in a vacuum. Astern wheels are incorporated. All turbine blading throughout is Monel metal.

Each engine set has double helical gearing consisting of main wheels driven by two pinions. Weight has been saved wherever possible by the extensive use of aluminium alloy, which, for instance, is used for the gear wheel covers and all fittings not liable to corrosion.

Steam entering the high pressure turbine nozzle chest is at 350 lb. per square inch pressure and 640 deg. Fah. temperature. The designed revolutions for 36 knots are :

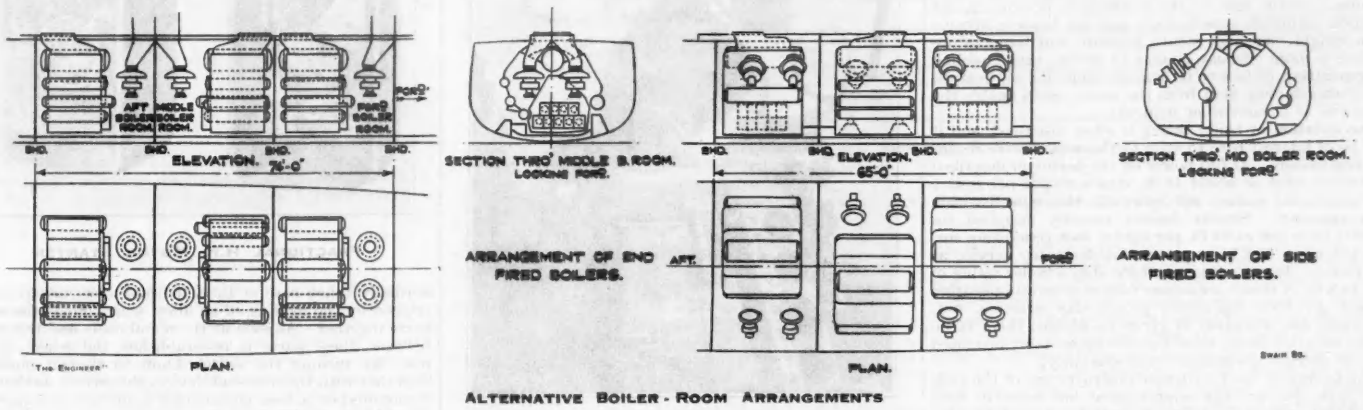
High-pressure turbines	3500 r.p.m.
Low-pressure turbines	2600 r.p.m.
Propellers	450 r.p.m.

The propellers are three-bladed, outwards turning.

The boiler units, illustrated above, are of the latest Yarrow water-tube type with Yarrow superheaters and air heaters. They are designed for :—

Working pressure	400 lb. per sq. in.
Blow-off pressure	425 lb. per sq. in.
Steam superheat temperature	670 deg. Fah.
Air temperature above atmosphere	About 250 deg. Fah.

The boilers themselves are each double flow. The gases pass on both sides of the saturated steam drum, and the portion so passing can be varied by operating the damper at the junction of the uptakes. The integral superheater consists of U tubes expanded into a drum and well inclined so as to be self-draining, while the drum itself conserves a valuable reserve of steam for manœuvring. It will be noted that, as the proportion of gases passing the superheater is regulated by moving the uptake damper, close control is obtained over the final superheat tempera-



ALTERNATIVE BOILER-ROOM ARRANGEMENTS

Another damper is arranged to shut off the air to the air preheater on the side of the boiler, through which the gases are not passing, thereby further increasing the temperature of the heated air and the efficiency of the boiler. This also prevents the corrosion of the air heater tubes. These two dampers are connected and operated in unison.

All drums are hollow forged with only the ends riveted,

* Institution of Engineers and Shipbuilders in Scotland, November 20th. Abbreviated.

and longitudinal riveted seams are entirely dispensed with.

The air heaters consist of horizontal steel tubes expanded into tube plates at each end, the air flowing through the tubes and the gases round the outside of the tubes. The air ducts are arranged to enclose the furnace and prevent the brickwork from reaching deleterious temperatures.

The total heating surface, including generating, superheating and air heating surfaces, is approximately 10,500 square feet per boiler unit.

Diffusers are fitted to the forced draught fans to ensure perfect ventilation of the boiler-rooms at cruising speeds. At full power the volume of air required for combustion and the type of diffuser adopted ensure a cool boiler-room. In this respect it is interesting to note that, on the full power trial which was run during the summer, the temperature in the boiler-room was 80 deg. Fah., and on the consumption trial 85 deg. Fah.

The total weight of machinery, auxiliaries, boilers, stern gear, and water in boilers and condensers is approximately 405 tons.

The six-hour full-power trial and the sixteen-hour consumption trial of one of the Glasgow-built vessels, run at the mouth of the Clyde, gave the following results, viz.:

Six-hour Full-speed Trial.

Speed	36·65 knots
Propeller revolutions	446 r.p.m.
S.H.P.	31,280
Superheated steam pressure at boilers	386 lb. per sq. in.
Superheated steam temperature at boilers	660 deg. Fah.
Boiler feed temperature	195 deg. Fah.
Stokehold air pressure	7·9in. W.G.
Oil fuel pressure at burners	115 lb. per sq. in.
Oil fuel temperature at burners	130 deg.Fah.
Air temperature at burners	307 deg. Fah.
Vacuum	28in.
Barometer	29·51in.
Fuel oil consumption for all purposes	0·75 lb./S.H.P./hour
Boilers in service	Three

Sixteen-hour Consumption Trial.

Speed	15·01 knots
Propeller revolutions	163·3
S.H.P.	1770
Superheated steam pressure at boilers	373 lb. per sq. in.
Superheated steam temperature at boilers	590 deg. Fah.
Boiler feed temperature	194 deg. Fah.
Stokehold air pressure	1·2in. W.G.
Oil fuel pressure at burners	112 lb. per sq. in.
Oil fuel temperature	155 deg. Fah.
Vacuum	29in.
Barometer	29·95in.
Air temperature at burners	330 deg. Fah.
Fuel oil consumption for all purposes	1·03 lb./S.H.P./hour
Boilers in service	One

The oil fuel used throughout these trials had a calorific value of approximately 19,000 B.Th.U. per lb., and was of the usual quality for British naval vessels. Measurements were carefully made in a calibrated tank, and in order to avoid any discrepancy and ensure accurate figures care was taken that the trim of the vessel was the same before and after each trial.

It will be noted that the mean speed on the six-hour trial was 36·65 knots, but on the trials of one of the later destroyers, run in Portugal, the speed exceeded 37 knots, and even at this speed there was ample margin of power and boiler capacity.

When the oil fuel tanks are full, the radius of action at 15 knots proves to be approximately 5450 knots.

If a comparison is made with a pre-war destroyer of the same power the increase in economy is considerable. The oil per S.H.P. per hour for full power of a 1914 destroyer was about 1·15, compared with 0·75 for the Portuguese destroyer and corresponding figures for the 15-knot consumption trial are 1·86 compared with 1·03, showing the very marked improvement now obtained at cruising powers.

The improved economy has been brought about partly by improvements in the main and auxiliary machinery and greater attention to feed heating, but mostly by the use of higher steam pressures and superheat and the adoption of air heaters.

The boilers installed in the Portuguese destroyers embody most developments now adopted in the latest designs of water-tube boilers for the merchant marine, as in both services economy is all-important.

In a warship weight has to be reduced to the minimum, and therefore careful consideration must be given as to whether increases necessary to secure additional economy can be afforded and very often the matter is one of compromise. In the case of the Portuguese destroyers, for instance, although superheaters and air heaters involve extra weight, the high steam pressure and temperature produce a more efficient quality of steam, thus enabling the generating surface to be smaller, while the air heaters, which absorb more heat from the gases, again enable the boiler size to be somewhat reduced.

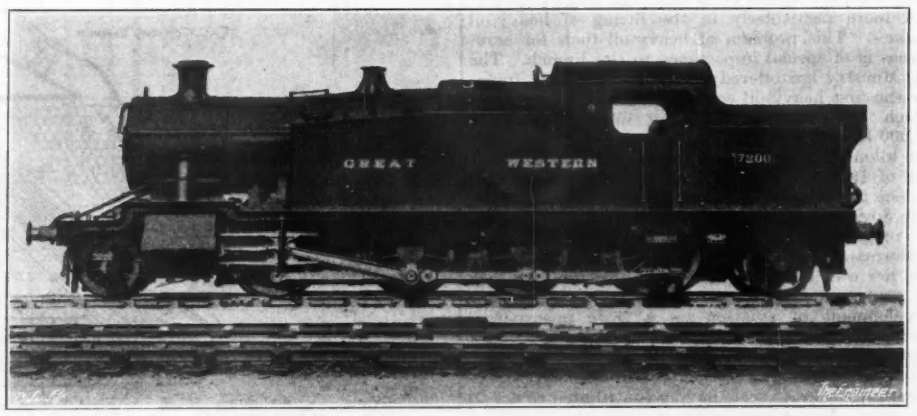
The question of boiler rating is often discussed, and it may be of interest here to refer to this aspect with regard to naval vessels. At full power on the destroyer described the boilers work at about 16 lb. steam output per square foot generating surface per hour, and this is well within their capacity. Similar boilers recently supplied for cruisers have run at 24 lb. per square foot generating surface per hour, and have given reliable steady service at this rating. In a modern merchant ship a boiler rating of 7 lb. to 8 lb. of steam per square foot of generating heating surface per hour represents present-day practice, but, providing due attention is given to design, there is no reason why this rating should not be appreciably increased without sacrificing efficiency and reliability.

The boilers of the Portuguese destroyer are of the end-fired type, but another improvement has recently been introduced with side firing in which the oil burners are placed fore and aft under a lower water drum. The side-fired boiler design, see page 521, enables important advantages to be obtained. The heat, particularly with large-size boilers, is distributed more evenly across the width of the furnace, resulting in improved efficiency and, as firing space at the end is dispensed with, the stokehold can be considerably shorter, as is clearly shown. This drawing shows three boilers, each in a single stokehold. The boilers are of the same size and steaming capacity, and the saving in length of the side-fired arrangement is about 12½ per cent. The side-fired design enables either the vessel to be shorter or the whole interior of the hull to be better arranged and more space given for cabins, crew's accommodation, &c. This design has been adopted for several foreign warships, and is being introduced into H.M.S. "Grenville," a flotilla leader, under construction at the present time by Yarrow and Co.

G.W.R. Heavy Tank Engines.

Not long ago the Great Western Railway Company created the "5200 class" of 2–8–0 tank engines, especially designed for dealing with the South Wales coal traffic from pit to port. Owing, however, to the falling off in this export trade, they were not required for this service, and have now been converted into 2–8–2 tank engines of the "7200" class, having larger coal and water capacity to make them suitable for main line service. The radial truck is of standard design, but with increased side play to enable engines to negotiate sharp curves.

The total wheel base is 35ft. 3in., and the coupled wheel base is 20ft., whilst the length over buffers is 44ft. 10in., this being the longest tank engine on the Great Western Railway.



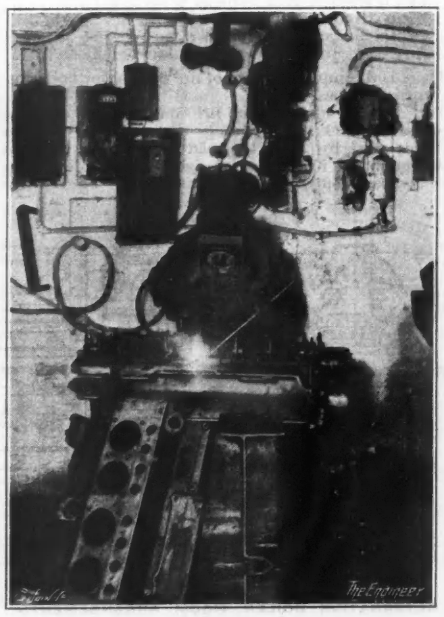
G.W.R. 2-8-2 Heavy Tank Engine

The principal dimensions are as follows:—

Two cylinders	19in. dia. by 30in. stroke
Boiler pressure	200 lb. per sq. inch
Water capacity of tanks	2500 gallons
Driving wheels	4ft. 7½in. diameter
Tractive effort	33,170 lb.
Coal capacity of bunker	6 tons
Weight in working order	92 tons 12 cwt.

An Electrical Process for Welding Aluminium.

Until recently the electric welding of aluminium castings was little more than an interesting laboratory experiment, and all commercial welding of this kind was done with an oxy-acetylene blow-pipe. As oxygen readily unites with aluminium at welding temperatures, the application of a flame containing oxygen causes the rapid formation of oxide, which is a poor conductor of heat, and before the metal can be welded the operator has to break through the oxide by a "puddling" process, or must dissolve it by the use of a special flux. But as an electric arc contains no oxygen other than that drawn from the air, it is evident that if aluminium can be welded electrically the formation of oxide will be greatly reduced. Another advantage that the electric arc has over the oxy-acetylene flame is that it is more localised. The heat of the oxy-acetylene flame is diffused over a fairly wide area, and as aluminium is a rapid conductor of heat it is difficult to weld any part of a casting composed of this material without other portions of the work being affected. As this tendency is considerably reduced with an electric arc, it is evident that if the arc can be used for welding aluminium the chances of distortion should be virtually eliminated and machining greatly minimised.



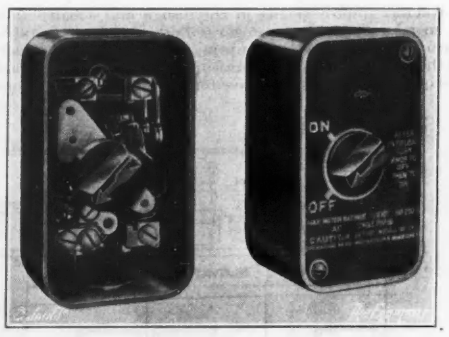
Welding Aluminium Crankcase

Barimar, Ltd., of 14–18, Lamb's Conduit-street, W.C.1, claims to have solved the problem of welding aluminium with the electric arc, and difficult examples of work, such as the repair of bearer supports that have been broken from the main casting and the repair of fractured bearing housings, present no difficulty. The repaired parts are said to show remarkable strength and to have perfect accuracy.

At a recent practical demonstration of the process we noted that D.C. was necessary to achieve successful results, and that, in addition to a special feed rod constituting the "welding electrode," a carbon electrode was employed in conjunction with a special flux. The rapidity with which the work was done was very surprising, but the manipulative skill of the operator is an important factor in attaining success, and it must not be imagined that experience in this particular field is unnecessary. The new development opens up many possibilities, particularly in connection with the heavier classes of work, and although the oxy-acetylene blow-pipe will not be discarded entirely, the electric arc process is expected to be employed widely in the future. The accompanying illustration shows welding work being carried out on an aluminium crank case.

A New Single-Phase Fractional Horse-power Motor Starter.

The small hand-operated switch starter shown in the accompanying illustration has been introduced by the British Thomson-Houston Company, of Rugby, for controlling and protecting single-phase fractional horse-power motors up to ¼ H.P. at voltages not exceeding 250. Both poles of the double-pole switch have silver to silver contacts, which open and close with a definite snap action. A trip-free service makes it impossible to hold the switch closed under injurious overload conditions, which are normally taken care of by a thermal over-current relay, tripped by the melting of an alloy which holds the small parts together. As soon as the metal cools and the union between these parts is re-established the relay can be reset by turning the switch knob to the off position. Together with the overload device, the switch mechanism is mounted on a base of moulded insulation and enclosed in a black enamelled steel case with an engraved aluminium cover with holes at the top and bottom to take ¾in. conduit, secured to the case by internal and external nuts.



Fractional H.P. Motor Starter

The renewal of 436 miles of permanent way during 1935 by the London and North-Eastern Railway Company will require between 30,000 and 40,000 tons of steel rails. The company also proposes to replace twenty-six railway bridges during the year.

High-Pressure Plant for Experimental Hydrogenation Processes.*

By A. T. BARBER, B.Sc. (Eng.), M.I. Mech. E.,† and A. H. TAYLOR, B.Sc. (Eng.), A.M.I. Mech. E.‡

Introduction.

The object of the paper is to present some of the engineering problems which have arisen during the progress of experimental work in connection with the hydrogenation of coal and tar at the Fuel Research Station, Greenwich. The scope of the paper is chiefly confined to high-pressure reaction vessels and their associated pipes and fittings.

In order to appreciate the principles involved, a brief description of the hydrogenation process is desirable. Heavy liquid hydrocarbons, or solid hydrocarbons such as coal, are subjected to the action of hydrogen, whereby a portion of the hydrogen enters into chemical combination, resulting in the formation of some lighter liquid hydrocarbons together with a certain amount of gas, and, when compounds containing oxygen are treated, water. The extent and speed of the reaction and the efficiency of the process are governed by the temperature and pressure at which it is carried out, and are also influenced by the presence of certain catalysts. Most of the experimental work at the Fuel Research Station has been carried out under a pressure of about 3000 lb. per square inch, and at temperatures ranging from 800 deg. to 950 deg. Fah., though pressures up to 6000 lb. per square inch have been used.

As originally carried out, the process for the continuous hydrogenation of coal necessitates the preliminary grinding of the coal so that it will pass through a sieve having, say, 20 meshes to the inch, then incorporating it with about 40 per cent. by weight of tar to form a stiff paste. After the process has started, a heavy liquid residue from the product may be used as the vehicle for the paste mixture. The small quantity of catalyst required is also added at the same time. The mixture is then fed into a paste pump whence it is forced into the reaction vessel maintained at the working pressure and temperature. The paste pump and connections are usually steam heated to assist the flow of the material. Hydrogen delivered from a multi-stage compressor is fed into the reaction vessel at the same time and during their passage through the vessel the ingredients are kept well mixed by means of a rotating stirrer. The product leaving the reaction vessel is a heterogeneous mixture of solids, liquids, and gases. It is passed through water-cooled coils to a separator maintained at a pressure of 900 lb. per square inch. The gases pass off at this point to a scrubbing tower, where the light spirit is washed out with gas oil, and the stripped residual gases containing about 65 per cent. of hydrogen may be returned to the compressor for recirculation. The remainder of the product, after being further freed at atmospheric pressure from dissolved gases, is then passed through a centrifugal separator to separate the true liquid product from solid residues and water. The resulting liquid resembles in appearance a somewhat viscid tar. After distillation the heavy fraction of the liquid from the centrifugal separator can be again utilised for the process as a vehicle for coal paste. The crude product contains about 10 per cent. of water and 50 per cent. of oil boiling below 360 deg. Cent. (680 deg. Fah.), of which 10 per cent. is spirit boiling below 200 deg. Cent. (392 deg. Fah.).

Some hydrogenation of tar has been carried out in the coal plant in a similar manner, but the process, as now operated, consists of pumping hydrogen and tar into a vessel having a reaction space filled with a suitable catalyst. The resultant product is drawn off and dealt with in the same way as the coal product, but the process is simplified by the absence of solid material. The liquid product resulting from the hydrogenation of low-temperature tar or tar oils is, of course, much lighter than that from coal and contains from 40 to 70 per cent. by weight of spirit boiling below 200 deg. Cent. (392 deg. Fah.).

2-Litre Autoclaves.

A large amount of preliminary work, such as the testing of catalysts, has been carried out in small discontinuous converters or autoclaves, each having a capacity of about 120 cubic inches. They are externally heated, either by gas or in an electric furnace. The converter containing the material to be treated is charged with hydrogen to an initial pressure, usually 1500 lb. per square inch. Heating to the reaction temperature of 850 deg. Fah. then follows; this takes about two hours and the temperature is maintained for a further two hours before cooling. The maximum pressure reached during a test is between 2800 lb. and 4500 lb. per square inch, depending on the amount of hydrogen absorbed during the reaction.

The earliest work on hydrogenation at the Fuel Research Station was carried out in 1924 in a simple form of autoclave which was constructed from a piece of old 10in. propeller shaft. It had a bore of 3½in. and a capacity of 125 cubic inches. The external diameter was at first left the same as the shaft from which it was made, but the converter was afterwards turned down to reduce the wall thickness to 1½in., so as to improve the heat flow. The single end cover was made with a plain spigot bearing on a copper ring, and no little care was necessary to ensure a tight joint for a pressure of 3000 lb. per square inch. The converter could be rotated or reciprocated for agitating the contents by means of a small steam engine. The heating chamber was of concrete, fitting close round the vessel, and heating was effected by means of gas burners in the lower part of the chamber.

In 1926, three 2-litre (120 cubic inch) discontinuous converters were obtained to continue the work of the old converter. They had a bore of 3½in. and a wall thickness of 1$\frac{1}{32}$ in. The cover was fitted with a double-cone plug, seating in a conical facing in the body, with the joint initially about 2in. from the end of the body. The cone angles were made 7 deg. and 21 deg. on the plug, and 14 deg. in the body, so that the joint was theoretically a line contact. Actually, this tends to become a slightly rounded conical surface by distortion in tightening up, and eventually the joint has a width of ⅛in. to ¼in., but once the technique of tightening up is mastered a tight joint can still be made. After prolonged use the joint line moves further into the body, when the angles of the plug and seating must be restored and the plug packed out from the flange to give the necessary clearance between the flange faces. The life of the original converter bodies was determined by the number of times the conical seatings could be recut, because when the joint line passed the back face of the body flange sufficient bulging took place to prevent a tight joint being made. Experience showed that a long parallel portion of the plug was not sufficient to ensure alignment, and it was found advisable always to caliper the distance between the flanges when tightening the bolts. The joint line in most of the converters subsequently made at the Fuel Research Station has, therefore, been formed initially much nearer the end of the body. In this way, the seatings can be refaced several times without passing beyond the restraining influence of the flange.

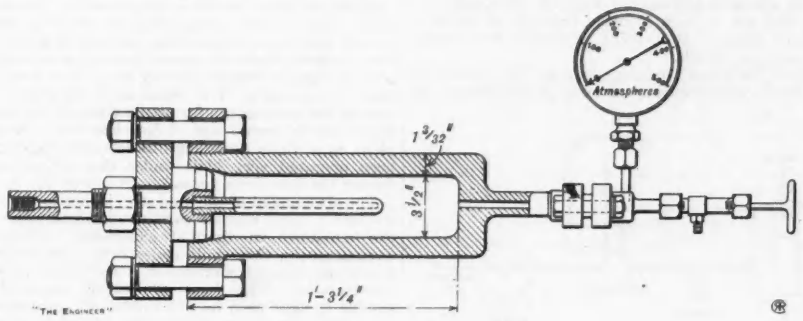


FIG. 1—2-LITRE AUTOCLAVE

Fig. 1 shows the construction of the most recent 2-litre converters made at the Fuel Research Station. Besides the three mild steel converters of this type originally obtained, fourteen have been made at the Fuel Research Station, of which nine were of mild steel and five of 3 per cent. nickel steel. They have all been turned from solid bar, and the flanges screwed on. In addition, three others were completed, but were found unfit for service at the first pressure test owing to porosity at the core of the billet.

As it may be wondered why mild steel has been used so much when such excellent alloy steels are available, it may be stated that it has been found that small amounts of certain elements have an appreciable effect on the rate and extent of the chemical reaction between hydrogen and coal. To obtain comparative results when experimenting with different catalysts, it is therefore desirable to use steel with a minimum alloy content; hence all the small converters used for preliminary coal hydrogenation experiments have been made of low-carbon steel. In all, about 2100 experiments have been carried out in the seventeen 2-litre converters, the joint being broken and remade between each experiment. The maximum number of experiments carried out in any one converter so far is 156.

A feature which was noticed in making some of the converters from solid bar was that after the first experiment the cone plug would not seat correctly in the body, and showed four high areas 90 deg. apart on the seating. This seemed to be due to internal stresses, which were imposed during the process of conversion of the bloom to round bar, followed by their subsequent release on heating. After boring and rough machining, the bodies of the converters are now heated to 1450 deg. Fah. and annealed before finishing. This has proved successful in overcoming the difficulty. The soft condition is no disadvantage as the mating surfaces become work-hardened in service.

Improvements have been made in the gas heating arrangements to obtain a more even temperature distribution along the converter, but it was necessary to use an electrically heated furnace to obtain a really flat temperature gradient along the full length of the converter. The converters are operated in two cubicles leading off from the high-pressure laboratory, each containing two converters. A curtain wall protects the operator from any possible danger. The converters are rotated at about 55 r.p.m. by means of a chain driven through countershafting by a 1 H.P. electric motor. A three-bladed stirrer lies loosely inside the converter.

To obtain a better mixture of the contents in converters for hydrogenating liquids, the bearings have been made spherical, and an excentric fitted at one end, thus giving an oscillating as well as a rotating motion. The driving sprocket is mounted excentrically on the converter, with the throw in the same direction as that of the excentric, so as to keep it approximately concentric with the axis of the bearings. A spring-loaded jockey pulley is fitted to equalise the tension in the chain. Hydrogen is supplied from a battery of bottles which are pumped up to a pressure of 1800 lb. per square inch by a compressor at intervals as required. All the converters are hydraulically tested to 6300 lb. per square inch before going into service.

Pressure Gauges.—The installation of the 2-litre converters in brick cubicles has proved effective protection in case of explosion. Two explosions which have occurred resulted in no more damage than the complete destruction of two pressure gauges. It may be remarked here that although in these two instances the gauges were undoubtedly overloaded, pressure gauges generally have been a weak spot in all the high-pressure plant. It seems impossible to obtain gauges for use at pressures between 3000 lb. and 6000 lb. per square inch, which can be relied on to retain their accuracy over a period of weeks, and many failures of the steel Bourdon tube have taken place without warning at or below the working pressure, which is never more than half the designed maximum. All gauges in use are regularly checked and calibrated by comparison with a standard test gauge on an oil screw press. It is also the authors' standard practice to fit celluloid fronts and open or cloth backs to the gauge bodies in order to minimise the risk to operators in the event of tube failure. Pressure gauges having Bourdon tubes of alloy steel are now being tried.

"Bergius" Coal Hydrogenation Plant.

In 1926 a plant for continuous operation, having a capacity of 1 ton of coal per twenty-four hours, was installed, as a result of the Department's interest in the British Bergius Syndicate. The lay-out of the plant, as originally arranged, is shown in Fig. 3, and details of the converters are given in Fig. 2.

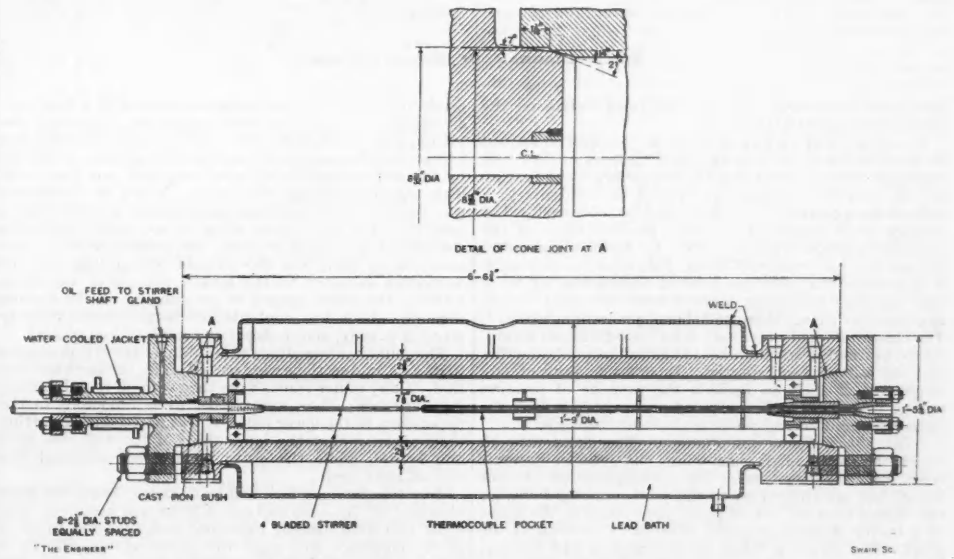


FIG. 2—CONSTRUCTIONAL DETAILS OF BERGIUS CONVERTER.

The three horizontal converters were arranged in series, the coal paste and hydrogen passing from one vessel to the next through connecting pipes at the ends. Both main cover joints are of the double-cone type, similar to those used for the 2-litre converters already described. A mild steel jacket filled with lead is welded to the converter body near the flanges. Heating is effected by four external longitudinal coal gas burners of the Bunsen type. Between the flanges the converter is completely immersed in liquid lead at the working temperature, and fairly even heating is thus obtained.

The connecting pipes are held in position by studs and a loose flange with a split collar, the latter bearing against a shoulder near the coned end piece, which is welded to the pipe. A dip pipe is welded to the outlet connection. This projects downwards in order to maintain the level of the liquid just above the top of the stirrer shaft. The stirrer consists of four flat blades mounted on four spiders and is rotated at about 55 r.p.m. by means of a dog on the

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‡ Scientific Officer II, Fuel Research Station, Greenwich.

stirrer shaft. The packing of the water-cooled gland for the stirrer shaft consists of white metal, oil, tallow, and graphite well mixed and compressed into rings. Two pyrometer pockets are fitted, one in the lead bath and one projecting inwards inside the stirrer from the front end cover. The weight of each converter complete is about 3½ tons, including 2 tons of lead.

Four converters were supplied with the plant; the material was understood to be a Krupp basic steel of the following percentage composition :—Carbon, 0·11; silicon, 0·16; sulphur, 0·018; phosphorus, 0·015; manganese, 0·55. The working life was estimated to be at least 1500 hours, after which it was recommended that a careful examination should be made for any weakening resulting from the high-pressure and high-temperature operating conditions, and particularly from hydrogen attack. Actually, only one converter approached the estimated life.

Internal Explosion.—The plant had been working for about 280 hours, though not without minor operating troubles, when an explosion occurred during a pressure test with air. The pressure was approaching 3000 lb. per square inch when it was necessary to warm up converter No. 3 in order to free the stirrer. Although the temperature was under 250 deg. Fah. when the burners were turned off, an explosion occurred shortly afterwards. No personal injury resulted, but considerable damage was done to the connecting pipes and valves, and the end cover joints of converter No. 1 were strained. The relief valve on the hydrogen supply line, which was set to discharge at 6000 lb. per square inch, opened but gave no effective protection to the plant. On this account it has not been considered necessary to fit pressure relief valves on the later experimental plants.

It is practically certain that the air pumped in formed an explosive mixture with the light vapours or dissolved hydrogen from the residue in the converters. The heating of converter No. 3 must have raised the contents to a critical temperature, at which ignition occurred. The damage done suggested that the greatest force of the explosion was felt in converter No. 1. As the temperature in converter No. 3 rose to 570 deg. Fah. after the explosion, it is possible that slow combustion commenced in No. 3 and that the hot gases were forced over into No. 2, igniting the mixture there and thence proceeding to No. 1. The converters had previously been tested with air several times, but had never been heated simultaneously, neither had the stirrers been rotated. In order to prevent any recurrence of such an ignition the practice of pressure testing with air was discontinued and only hydrogen has since been used for any pressure above atmospheric.

Stirrer Shaft Gland and Packing.—The gland through which the stirrer shaft passes into the cylinder presents some interesting features. The driving pulleys are not keyed, but are clipped on to the shaft, and the belts are run rather slack so that slipping may occur in the event of a stirrer sticking, in order to prevent twisting of the shaft. The thrust is taken on an external ball bearing. The depth of the stuffing-box is 9in. and the packing consists of rings made from white metal ribbon, graphite, tallow, and oil, moulded to shape in a hand press. A neck ring is inserted at the inner end of the stuffing-box, behind which heavy oil is supplied from lubricators of the Moscrop type to seal and lubricate the gland. The stuffing-box is also cooled by an external water jacket. When properly fitted and attended to, these packings are very effective and perfectly tight, but if the oil supply is stopped for any reason paste from the converter may creep past the neck ring into the white metal packing and cause it to seize to the shaft. The result is apt to be disastrous, as, for instance, on one occasion when the oil supply had been interrupted for about an hour. Twelve hours later, after an attempt had been made to take up the first signs of leakage, the packing gave way and the contents of the vessel were discharged through the gland and ignited, causing a fierce fire which destroyed the driving belts and did other damage. The engineer in charge was watching the gland at the time, but escaped without hurt. It may be mentioned that it has been the practice on this plant to keep a number of gas burners alight in various positions for the definite purpose of igniting any leaking gas or vapour before it has time to form an explosive mixture with the atmosphere of the building. An explosion would, of course, cause far greater damage than a simple fire.

Failures of Mild Steel Converters.—When the plant had been working for a total of 463 hours it was necessary to take the first converter out of service. It had been used for some time for hydrogenating tar, and continual leaks had been experienced at an end cover joint. The converter was removed and the seatings of body and spigot were skimmed in the lathe. Both seatings showed slight pitting after skimming, but as this did not look serious the converter was re-installed and a tight joint made. After only twelve hours, however, serious leakage took place and on examination a deep groove was found across the seating. Another cut was taken off the seating on the converter body in the lathe. Considerable pitting was exposed, which increased with further removal of metal. It being obvious that a satisfactory joint could not be made, the spare converter was installed.

On further examination numerous black streaks were found running longitudinally for several inches at the faulty end of the converter, the ends of which showed as pits in the seating. It appeared as if the vessel had been forged from a badly piped ingot. as no serious attack by hydrogen could have occurred at this point. The converter had, however, received the worst shock of the explosion already mentioned. The final grooving across the seatings was no doubt erosion caused by the passage of hydrogen and tar at high velocity through an initially small fissure situated at a point weakened by original faults or chemical attack.

After about 700 hours' working converter No. 2 suddenly ruptured while hydrogenating tar under normal operating conditions. The rupture was accompanied by a loud roar as the contents escaped and caught fire, splashing the molten lead about the room. The fire soon subsided and except for a fracture in the roof sheeting where it was hit by the cowl of the flue chimney over the converter, very little material damage was done. When the converter was cooled and dismantled examination showed that a long crack had opened out along the top centre inside the converter for a length of 28in., the greatest width of the crack being ⅛in. On the outside was a long shallow depression adjacent to the middle portion of the crack inside. The actual length of the opening on the outside through which the contents discharged was probably about ⅜in. only, and it closed up completely on cooling.

The converter was afterwards cut in halves at right angles to its axis, and sections were parted off fo. further examination. Many minor cracks were then seen all round, radiating outwards; they were rather more numerous in the upper than in the lower half. It was noted during cutting these sections that the inner third of the wall was hard and brittle, while the outer portion left the tool like normal mild steel.

New converters, which will be discussed later, had been obtained by this time and one of these was installed. The other two were visually examined and appeared to be in good condition. The plant was operated normally for a period, after which the conditions were changed. The first converter in the series was used as a preheater for hydrogen only, No. 2 being charged with 50 lb. coal through which hydrogen was passed at a pressure of 3000 lb. per square inch, while the liquid products were condensed in converter No. 3, which was water-jacketed.

Under these conditions converter No. 1a (which replaced No. 1) ruptured after 814 hours' total working life, the escaping gas igniting immediately. In this case, owing to the position of the converter, more damage was done by the resulting fire. The stirrer driving belts were destroyed, also a heavy rope mantlet which formed the upper extension of the screen wall between the converters and control room. Lead was melted from the roof glazing bars and the asbestos roofing sheets broken. The appearance of the cylinder after the fracture was precisely similar to that of converter No. 2, and it is noteworthy that, in spite of the extent of deterioration of the metal, the vessel did not explode violently in either case. The actual explosion on this occasion was no louder than the popping of a boiler safety valve.

The last of the mild steel converters, No. 3 in the series, was withdrawn after 1238 hours' service under full working conditions. On examination it was found that embrittlement of the steel had occurred to a considerable extent; in fact, failure was probably not far distant. It is probable that its longer life, compared with converters Nos. 1 and 2, was due to the lower concentration of hydrogen in it.

Apart from the action of hydrogen in decarburising the steel and penetrating the crystal boundaries, the stress of 6 tons per square inch is high for a mild steel operating at 850 deg. to 900 deg. Fah. The "time yield" stress at this temperature is well known to be only about 5 tons per square inch. The failure of these vessels would appear to be the result of hydrogen reducing the cohesion of the crystals at the inner surface, with subsequent separation of the crystals under the stress. The initial stress, always high, was increased as the effective thickness of the walls was reduced. The effect of both the hydrogen attack and the stress was therefore cumulative, and the outer ring finally failed in tension.

Alloy Steel Converters.—Some time before the failure of any of the converters, inquiries had been made in this country for replacements made of a more suitable steel, and in 1928 three converters were obtained from Messrs. Hadfield's, of Sheffield, in their "ERA HR" steel, a heat-resisting steel which is also resistant to the action of hydrogen. The percentage composition is—carbon 0·2, chromium 22·0, nickel 7·0, tungsten 4·0, silicon 1·75. At the makers' suggestion these were made as castings instead of forgings, as it was thought that it might not be possible to avoid small forging cracks. Actually, the production of the castings was not an easy matter, as several had to be discarded on account of porosity. One was accepted after the porous portion had been plugged with a tightly fitting screwed plug, and has given no trouble in service. The oldest of these alloy steel converters has been in use for about 600 working hours, and has so far shown no sign of deterioration. Owing to the plant as a whole becoming obsolete, the converters have been operated very little under the original conditions during the last three years.

The attachment of the mild steel jacket to the alloy steel converter body needed careful consideration, owing to the difference in thermal expansion. Under certain circumstances, this would cause very high stresses in the jacket and welded connection, if the latter were of rigid construction. The form of flexible connection, very similar to that used on the mild steel converters, which was recommended to the makers has given entire satisfaction. Before the jackets were attached, the alloy steel converters were hydraulically tested to 6000 lb. per square inch. Measurements taken on one vessel during the test showed a diametral expansion of 0·0022in. on 12·5625in., and a longitudinal expansion of 0·005in. on 64,866in.

High-pressure Valves.—The discharge of hydrogenated material from the continuous coal plant has produced some interesting experiences. It will be realised that as the ground coal may contain pieces of shale, &c., as large as $^{1}/_{20}$in. diameter, which pass through the plant unchanged, the opening of the discharge valve must be at least equal to the size of these pieces, and an opening of this amount on a conical seated valve of even quite small diameter would allow of a discharge, at the high working pressure, greatly in excess of the capacity of the plant. Furthermore, the scouring effect of the mixture at that pressure washes away the metal of the valve and seat in an astonishingly short time. The main control valve for the discharge is a disc valve sliding over a small orifice (3 mm. in diameter) in the valve seating. This is operated intermittently so that discharge takes place over the full bore for short periods at intervals of about one minute. Even with this type of valve, wire drawing is so severe that seatings made of, for example, high-carbon high-chromium steel, and 18 per cent. tungsten steel in its hardest possible condition, have been destroyed in a few hours. The only material found to be of any use for this purpose is tungsten carbide. The authors believe this can only be obtained in Germany, and being of diamond hardness it is very difficult to work. It is, moreover, extremely brittle, but if handled carefully it will last indefinitely.

(To be continued.)

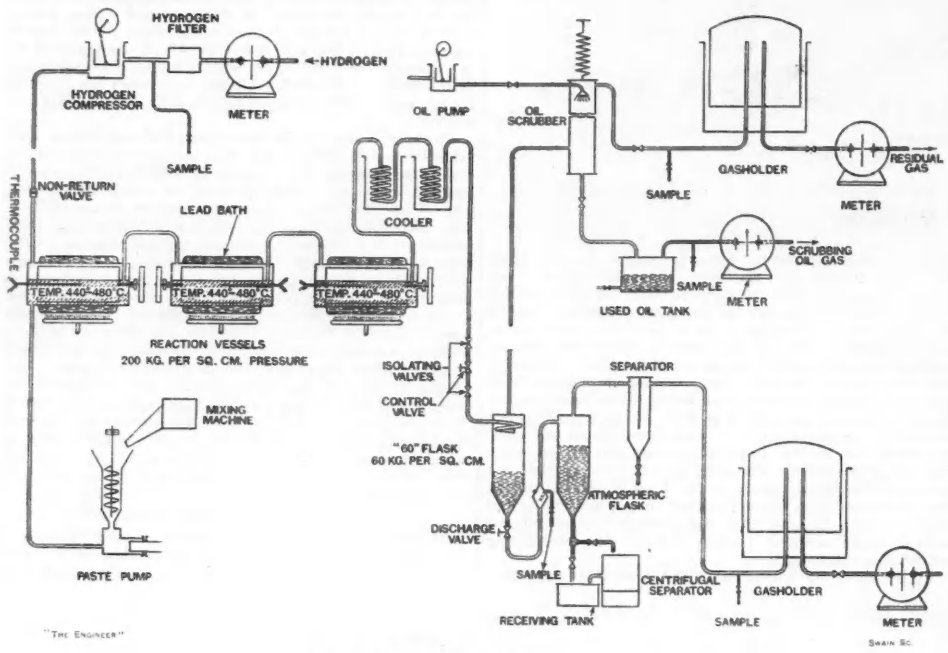

FIG. 3—DIAGRAM OF BERGIUS PLANT

WATERWORKS PRACTICE IN AMERICA.

APART from studies in new and increased supplies of water and greater economies in the utilisation of existing sources, due to the severe drought of 1934, many improvements and developments have been made in waterworks plants, particularly as to water treatment. In settling basins it has been found that where flocculators are installed the turbidity is 50 per cent. less than in water from basins not so equipped. Slow and gentle mixing for longer periods of time than have been usual is found of high advantage. Rectangular mixing tanks with variable-speed power-driven stirrers, for preliminary treatment, have proved effective for variable flow, being low in head consumption and resulting in economy of chemicals. Stirring may continue for thirty to forty-five minutes. At an iron removal plant a master controller maintains the water level on the filters between prescribed limits and also divides the flow equally among the filters, regardless of the total output of the plant. There is also increasing use of instruments, such as synchronous electric clocks for Venturi meters and filter gauges, and telemeter gauges for transmitting to a central point the readings of flow and water level. Research in the chemical and mechanical aspects of coagulation and sedimentation has led to great improvement of water before its filtration, while removal of objectionable tastes and odours has been advanced by the use of activated carbon and chloramine sterlisation. This treatment also improves the appearance, a dose of five to seven parts per million on highly coloured surface water absorbing the musty vegetable odour and assisting in the coagulation of the vegetable colouring matter. Chemical treatment, however, necessitates more attention, which cannot always be assured at small plants. Zeolites, and particularly artificial zeolites, are being used increasingly. Where carbon dioxide in the water was so high as to cause disintegration of the zeolite, both alkali and aeration have been effective in reducing the carbon, the latter method being the less expensive. Aerators of upward-flow type have also been used instead of coke trays for iron removal.

Markets, Notes and News.

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer. A comprehensive list of the prices of materials mentioned below will be found on the next page.

British Price Movements.

Slowly but surely the control of the British steel makers is being extended to cover products which have previously enjoyed a free market. The latest movement in this direction is to bring boiler plates under the control of the associated makers and to establish a fixed price of £9 7s. 6d. less a rebate of 15s. to those users who purchase their supplies exclusively from members of the Association. For some time discussions have been proceeding between the manufacturers, but it was only recently that any real progress was found to be possible. The case of boiler plates is perhaps exceptional, since the absurd position had been reached in which this material, in spite of the greater care required in manufacture and selection, was obtainable at lower prices than those asked for ordinary ship and tank plates, which have long been controlled. In fact, figures as low as £7 15s. have been accepted by manufacturers under the pressure of competition. The British steel makers have also adopted a new extras list. Apparently basis prices have not been altered, but a number of extras, the revision of which was long overdue, have been reduced. This step should go far to meet the views of export merchants, who for years past have complained that the old extras greatly increased the difficulty of selling British steel in overseas markets.

Import and Export Statistics.

The import and export figures of the Board of Trade for October indicate a decided expansion in the volume of business, the improvement in the export figures being particularly noticeable. The total exports for the ten months ended October 31st were 1,847,317 tons, compared with 1,565,583 tons for the corresponding period of 1933, the value of the goods exported being respectively £28,625,149 and £24,331,640. The imports for October reached 120,197 tons (£803,710), compared with 89,525 tons (£615,559) in September, the figures for the ten months being 1,148,375 tons (£7,719,837). The export figures, however, include certain items not given in the import returns. The import figures disclose a tendency towards an increase in most branches. Pig iron to a total of 13,096 tons was imported in October, compared with 9358 tons in September, but the October total included 12,049 tons of Indian iron. There was a notable jump in the imports of blooms and billets to 40,865 tons in October, compared with 26,932 tons in September, 8057 tons coming from British countries, although the precise origin is not given. Belgium supplied 21,166 tons and France 7460 tons. Imports of sheet bars also increased from 4934 tons in September to 6806 tons in October, practically all of which came from Belgium. Apparently the importation of tin-plate bars from Belgium has been resumed, and an item of 1022 tons appears under this heading. Imports of bars, rods, angles, shapes, &c., rose from 17,152 tons in September to 21,475 tons in October. Girders, beams, joists, and pillars were imported in October to a total of 8237 tons, compared with 5271 tons in September, the increase being chiefly due to high imports from Belgium, which totalled 6140 tons. There is little change recorded in the supplies of foreign hoop and strip, which reached 3861 tons in October, against 3762 tons in the previous month. By far the largest proportion of the imports came from Belgium with 55,246 tons, "British countries," excluding India, coming next with 13,713 tons, France with 11,126 tons, followed by Luxemburg with 9346 tons, Germany with 9258 tons, and Sweden 5672 tons.

Our Improving Export Trade.

The export returns are satisfactory, inasmuch as they show an increase in most departments. The quantity of pig iron sent abroad totalled 12,269 tons in October, compared with 7744 tons in September, whilst the exports of sheet bars and tin-plate bars, wire rods and bright steel bars rose to 2738 tons from 1210 tons in September. Exports of general descriptions of steel increased to 18,933 tons in October, compared with 16,547 tons in September, the best customer in October being South Africa with 4390 tons and then India with 4363 tons. The total of plates and sheets not under ⅛in. thick sent abroad decreased to 13,274 tons, against 14,272 tons in September. The exports to foreign countries fell from 8744 tons in September to 7883 tons in October. Plates and sheets under ⅛in. thick showed an increase to 15,887 tons, against 12,480 tons, the improvement being largely due to an increase in the exports to Canada and Japan. There was also a welcome increase in the exports of galvanised sheets from 16,172 tons in September to 22,941 tons, whilst the exports of tin-plates rose from 33,648 tons to 36,365 tons in October. There was, however, a decline in the tonnage of railway material sent abroad from 23,741 tons in September to 16,013 tons in October. This was partly accounted for by a drop to 9277 tons in the exports of rails from 13,257 tons in September and of sleepers and fish-plates to 2177 tons from 3449 tons. South Africa received the largest quantities of railway material, the total being 5504 tons, compared with 3012 tons in September; 2036 tons also went to British East Africa. Of the total quantities exported in October, the largest tonnage went to South Africa, the figure being 31,314 tons, India coming next at 21,930 tons; Australia, 17,574 tons; and Canada, 15,700 tons. Amongst the foreign countries Denmark took the largest total with 10,613 tons, Argentina being close behind with 10,167 tons. China took 6841 tons, Holland 6561 tons, Russia 5863 tons, and Norway 5520 tons.

The Pig Iron Market.

The tendency towards easier conditions which has developed in some branches of the iron and steel trades has not affected the pig iron market, and during the past week business has been more active than at any time this month. On the North-East Coast a number of contracts have been placed for delivery over the first quarter of next year and in some cases beyond. Deliveries continue to be made on a substantial scale and the Scottish light castings industry is taking good quantities of foundry iron. In fact, the total sales and deliveries have been in excess of production and stocks have had to be drawn upon. In these circumstances the market seems confident that the production will have to be increased in the New Year, if not before. Export business, however, has been insignificant, as the makers do not like taking the risks involved in this trade. A certain amount of iron, however, has been sent abroad through merchants. The demand for Midland iron has been well maintained and many ironmasters report that November has been the best month so far in the second half of the year. The market is expected to become more active still in December, when a number of contracts will come up for renewal. The steady conditions which have ruled in the Scottish pig iron industry for the past few months show no signs of deteriorating. All the foundry iron produced in Scotland is passing into consumption; stocks are not heavy and in some cases are reported to be decreasing, in spite of the imports of English and Indian iron. The consumption of pig iron in the Lancashire district is on a good scale, although it does not seem to have expanded much of late. Users are taking good deliveries, and some of the branches, such as the general engineers and the machinery makers, anticipate increased requirements over the next few months. The production of basic iron in all districts has been maintained, but comparatively little of this comes upon the open market. Business in hematite with the North-East and North-West Coasts has improved slightly after a period of rather quiet buying, and there has been no cessation in the deliveries to consumers, which have been kept at a high level.

British Iron and Steel Production.

The British Iron and Steel Federation, in its monthly statement for October, reports that ninety-seven furnaces were in blast at the end of the month, a net decrease of one, two furnaces having been blown in and three blown out. Particulars are not given in the report, but of the two furnaces which were blown in one was at the works of G. and R. Thomas, Ltd., of Bloxwich, South Staffs., and one at John Lysaght, Ltd., Scunthorpe, Lincs; whilst one furnace was put out of commission by the Frodingham Iron Company, Ltd., one by John Hickman and Sons, Ltd., of Bilston, and one by the Lilleshall Company, Ltd., of Shifnal, Salop. The production of pig iron during October amounted to 527,100 tons, against 500,300 tons in September and 373,300 tons in October of last year. Of the October total, 131,700 tons was hematite, 267,200 tons basic, 112,500 tons foundry, and 7300 tons forge pig iron. The output of steel ingots and castings totalled 812,000 tons in October, compared with 734,700 tons in the previous month and 668,300 tons in October, 1933. It is interesting to note that the production of pig iron for October is the highest since July and of steel since March of this year. The following table shows the monthly average of pig iron, steel ingots and castings over a series of years and the output for the past four months of this year:—

	Pig iron, tons.	Steel, tons.
1913—Monthly average	855,000 ..	638,600
1920 " "	669,500 ..	755,600
1929 " "	632,400 ..	803,000
1931 " "	314,400 ..	433,500
1932 " "	297,800 ..	438,500
1933 " "	343,600 ..	583,600
1934—July	528,300 ..	718,200
August	503,300 ..	667,000
September	500,300 ..	734,700
October	527,100 ..	812,000

Scotland and the North.

The Scottish steel works are operating practically at full time and a considerable proportion of their output is going to the shipyards, although recently there has been an active demand from the constructional engineers, the bridge builders, and machinery makers. A fair number of orders for small craft have been placed with Clyde yards recently, but the steel makers would feel more confident if contracts for some larger vessels were placed, as they are working off orders for shipbuilding steel much more rapidly than new business is coming forward. Active conditions have developed in the sheet industry, and there has been a strong demand for the heavier gauges on home account. The requirements of the motor trade are also increasing and are providing a substantial amount of work for this branch. The Scottish re-rolling industry is working irregularly. Business in small bars in particular has been quiet and this is attributed to a great extent to the competition of Continental steel. On the other hand, there has been a fair demand for small sections and hoops. One of the complaints of this industry is that current business consists of a multiplicity of small orders covering a considerable range of sizes. Cheerful conditions continue to rule in the Lancashire market, and although business has not noticeably increased in volume during the past week or two, it has been maintained at a respectable level. An active demand exists for the lighter descriptions of steel materials and the constructional engineers are taking good quantities of joists and sections. The locomotive builders have a fair amount of work in hand, and lately they have placed some good orders for boiler plates, although this was before the material was brought under control by the Steel Association. The re-rolling works are moderately well employed, but competition in this district between associated and unassociated works seems to have been even keener than in other parts of the country. Little, however, is heard of Continental material reaching Lancashire consumers. The North-West Coast steel works expect to be fully employed until the end of the year, although the business which is reaching them consists chiefly of small orders. The hoop mills have a considerable amount of work in hand, but other departments are not so busy as they would like to be.

Current Business.

An order for a 3300-ton cargo ship has been placed with Hawthorn, Leslie and Co., Ltd., of Hebburn-on-Tyne, by the Tyne-Tees Steamship Company. A new battery of coke ovens has been put into operation at the Cargo Fleet Ironworks of the South Durham Steel and Iron Company, Ltd. This extension completes the new silica coke oven plant which has been installed by this company within the past two years and which will have a coke output capacity of over 5000 tons per week. The ovens are of the "Kogag" type, built with the "Goldschmidt" flue for an increased yield of benzole, and is the first battery of ovens to be built in this country on this principle. An extended and remodelled by-product recovery plant is also being installed. Peter Brotherhood, Ltd., engineers, of Peterborough, announce that they have received contracts for the supply of a number of compressors. Brotherhood-Ricardo high-speed Diesel engines, steam turbines, British Junker Diesel engines, and steam engines and generating sets, as well as for water cooling towers, refrigerating plant and fabricating steel work. Dorman, Long and Co., Ltd., have secured a contract for the steel work and sheeting required in connection with the construction of the new air base at Dhibban, Iraq, for the Air Ministry. The contract will involve the supply of about 5000 tons of structural steel work, 2500 tons of corrugated sheeting, and 500 tons of reinforced rods. The London Passenger Transport Board has also placed an order with this company for 5730 tons of tramway rails; and another contract for 1125 tons of rails and fish-plates for export has been secured from the Peruvian Corporation. The Department of Overseas Trade reports that the following contracts are open for tender:—East Indian Railway: supply of six 4–6–0 locomotive superheater conversion boilers and materials (Calcutta, December 7th); cylinder and motion parts and material for the superheater conversion of 0–6–0 S.G. and 2–6–4 B.T. class engines; twenty-two 0–6–0 and 2–6–4 conversion boilers with fittings for conversion of 0–6–0 and 2–6–4 engines (Calcutta, December 18th); Egypt, Ministry of Communications: multitubular return-tube marine boiler for a tug (Alexandria, December 17th); Lourenço Marques, Ports and Railways Directorate: ten electric portable cranes of 3 metric tons capacity (Lourenço Marques, December 21st).

Copper and Tin.

The position in the copper market seems to change according to reports, favourable or otherwise, concerning the progress of the negotiations for restricting output. At the beginning of this week rumours that the American producers had agreed to reduce their production by one-third created a distinctly firmer tone. Later, however, it was stated that this proposal was conditional upon the producers in other countries cutting their outputs by 25 per cent. The fact, however, that the negotiations are still going on and that the problem is being seriously tackled has had a beneficial effect upon the tone of the market. The quotation for electrolytic copper now stands at 6·80c., or about £30 12s. 6d. c.i.f. It is understood that one of the chief difficulties has been to bring the Belgian and Chilean producers into the scheme. American figures give the world production of refined copper in October as 118,070 tons, an increase of 4600 short tons. The American share of the production was 31,644 tons. The world consumption increased about 24,300 tons to 121,604 tons, whilst the world's stocks are reported to have been reduced by about 8500 tons, leaving a total of 488,000 tons. There has been a good deal of selling in the standard copper market which has been partly accounted for by bull speculators getting rid of their commitments. It has been reported that copper which had been lying in Germany and which the German consumers were unable to take up owing to the difficulties of obtaining exchange has been brought back to this country and sold. . . . The tin market remains in a lethargic and uninteresting condition. The control exercised over the market has discouraged speculators, although it has been successful in establishing the price at around £228 10s., a figure which apparently the International Pool considers satisfactory. Recently there was a considerable amount of bear covering for December and early January positions, and it was assumed that this was against speculative sales made some time ago. In other respects the market presents no new features. Business with America has been of small account and transactions with the Continent have been limited to an occasional odd parcel.

The Lead Market.

Prices in the lead market have fluctuated within a narrow margin, but except that values are still regarded as being too low the situation is fairly satisfactory. A large tonnage of lead is passing into consumption, and the deliveries of one branch alone—the lead pipe and sheet manufacturers—totalled 13,000 tons in October. The arrival of a cargo of Mexican lead had a somewhat depressing effect for a short time, but after this had been absorbed the appearance of the market improved. Russia also came into the market for a fair quantity, and some of the foreign lead was taken up on arrival by consumers who were prepared to pay the duty rather than await the delivery of Empire brands, for which premiums of 20s. for prompt and 15s. for forward are still quoted. In America quiet conditions rule, and buyers appear to be limiting their purchases to small parcels, with the result that the price has fallen to 3·55 c. per lb. New York. The position in America, however, has no more than a sentimental effect upon the London market.

Current Prices for Metals and Fuels.

Makers' official home trade prices, per ton, delivered buyers' stations. Sections, joists and plates are subject to a rebate to home users purchasing only from associated British Steelmakers: joists, 22s. 6d.: plates and sections, 15s. Export orders of 250 tons and over may be subject to special quotations.

PIG IRON.

	Home. (*D/d Teesside Area*) £ s. d.	Export. £ s. d.
N.E. Coast—		
Hematite Mixed Nos.	3 8 6	3 0 0
No. 1	3 9 0	3 1 0
Cleveland— (*D/d Teesside Area*)		
No. 1	3 10 0	3 4 0
No. 3 G.M.B.	3 7 6	3 1 6
No. 4 Forge	3 6 6	3 0 6
Basic (*Less 5/- rebate*)	3 7 6	—
Midlands—		
Staffs.— (*Delivered to Black Country Station*)		
North Staffs. Foundry	3 11 0	—
„ „ Forge	3 6 6	—
Basic (*Less 5/- rebate*)	3 12 6	—
Northampton—		
Foundry No. 3	3 7 6	—
Forge	3 2 6	—
Derbyshire—		
No. 3 Foundry	3 11 0	—
Forge	3 6 0	—
Scotland—		
Hematite, f.o.t. furnaces	3 11 0	—
No. 1 Foundry, ditto	3 12 6	—
No. 3 Foundry, ditto	3 10 0	—
Basic, d/d (*Less 5/- rebate*)	3 7 6	—
N.W. Coast—		
Hematite Mixed Nos.	3 12 6 d/d Glasgow 4 0 6 „ Sheffield 4 5 6 „ Birmingham	

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
Lancs.—		
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
S. Yorks.—		
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
Midlands—		
Crown Bars	9 15 0	—
Marked Bars (Staffs.)	12 0 0	—
Nut and Bolt Bars	7 5 0 to 7 15 0	—
Scotland—		
Crown Bars	9 12 6	9 5 0
Best	10 2 6	9 15 0
N.E. Coast—		
Common Bars	9 12 6	8 15 0
Best Bars	10 2 6	9 15 0
Double Best Bars	10 12 6	10 0 0

STEEL.

	Home. £ s. d.	Export. £ s. d.
London and the South—		
Angles	8 10 0	7 7 6
Tees	9 10 0	8 7 6
Joists	8 17 6	7 7 6
Channels	8 15 0	7 12 6
Rounds, 3in. and up	9 10 0	8 7 6
„ under 3in.	8 14 6	—
Flats, 5in. and under	8 14 6	7 2 6
Plates, ¼in. (basis)	9 0 0	7 15 0
„ 5/16in.	9 5 0	8 0 0
„ ⅜in.	9 10 0	8 5 0
„ 7/16in.	9 15 0	8 10 0
„ ½in.	9 10 0	8 5 0
North-East Coast—		
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Plates, ¼in.	8 15 0	7 15 0
„ 5/16in.	9 0 0	8 0 0
„ ⅜in.	9 5 0	8 5 0
„ 7/16in.	9 10 0	8 10 0
„ ½in.	9 5 0	8 5 0
Boiler Plates, ¼in.	8 5 0 .. 7 15 0 to	8 2 6
Midlands, and Leeds and District—		
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¼in. (basis)	8 17 6	7 15 0
„ 5/16in.	9 2 6	8 0 0
„ ⅜in.	9 7 6	8 5 0
„ 7/16in.	9 12 6	8 10 0
„ ½in.	9 5 0	8 5 0
Boiler Plates, ¼in.	8 5 0 .. 7 15 0 to	8 2 6

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
Glasgow and District—		
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¼in. (basis)	8 15 0	7 15 0
„ 5/16in.	9 0 0	8 0 0
„ ⅜in.	9 5 0	8 5 0
„ 7/16in.	9 10 0	8 10 0
„ ½in.	9 5 0	8 5 0
Boiler Plates	8 5 0 .. 7 15 0 to	8 2 6
South Wales Area—		
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 0
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¼in. (basis)	8 17 6	7 15 0
„ 5/16in.	9 2 6	8 0 0
„ ⅜in.	9 7 6	8 5 0
„ 7/16in.	9 12 6	8 10 0
„ ½in.	9 10 0	8 5 0

Ireland—	Belfast. £ s. d.	Rest of Ireland. £ s. d.
Angles	8 12 6	8 15 0
Tees	9 12 6	9 15 0
Joists	9 0 0	9 2 6
Channels	8 17 6	9 0 0
Rounds, 3in. and up	9 12 6	9 15 0
„ under 3in.	9 2 0	9 4 6
Plates, ¼in. (basis)	9 0 0	9 2 6
„ 5/16in.	9 5 0	9 7 6
„ ⅜in.	9 10 0	9 12 6
„ 7/16in.	9 15 0	9 17 6
„ ½in.	9 12 6	9 15 0

OTHER STEEL MATERIALS.

Sheets.	Home. £ s. d.	Export. £ s. d.
10-G. to 13-G., f.o.r.	9 0 0	8 15 0
14-G. to 20-G., d/d	10 5 0	9 0 0
21-G. to 24-G., d/d	10 10 0	9 5 0
25-G. to 27-G., d/d	11 2 6	9 17 6

The above home trade prices are for 4-ton lots and over; 2-ton and 4-ton lots, 10s. per ton extra; and under 2-ton lots, 30s. per ton extra.

Galvanised Corrugated Sheets, Basis 24-G.

Home.	£ s. d.
4-ton lots and up	13 0 0
2-ton to 4-ton lots	13 7 6
Under 2 tons	15 0 0

Export: £16 12s. 6d., c.i.f. duty paid India.
„ £11 5s. 0d., f.o.b. other markets.
„ Scandinavian Markets free.

Tin-plates.
20 by 14 basis, f.o.b. Bristol Channel ports, 18/2.
Tin-plate Bars, d/d South Wales Works, £5 7s. 6d.

Billets.	£ s. d.
Basic (0·33% to 0·41% C.)	6 12 6
„ Medium (0·42% to 0·60% C.)	7 2 6
„ Hard (0·61% to 0·85% C.)	7 12 6
„ „ (0·86% to 0·99% C.)	8 2 6
„ „ (1% C. and up)	8 12 6
Soft (up to 0·25% C.), 500 tons and up	5 10 0
100 tons	5 15 0
Rails, Heavy, 500-ton lots, f.o.t.	8 10 0
„ Light, f.o.t.	7 10 0

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	3/3 per lb.	
Ferro Tungsten	3/- per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£23 0 0	7/-
„ „ 6 p.c. to 8 p.c.	£21 12 6	7/-
„ „ 8 p.c. to 10 p.c.	£21 12 6	7/-
„ „ Specially Refined		
„ „ Max. 2 p.c. carbon	£34 0 0	11/-
„ „ „ 1 p.c. carbon	£38 15 0	12/-
„ „ „ 0·70 p.c. carbon	£42 0 0	12/6
„ „ „ carbon free	10d. per lb.	
Metallic Chromium	2/5 per lb.	
Ferro Manganese (loose)	£10 5 0 home	
„ Silicon, 45 p.c. to 50 p.c.	£13 0 0 scale 5/- p.u.	
„ „ 75 p.c.	£18 7 6 scale 6/- p.u.	
„ Vanadium	12/8 per lb.	
„ Molybdenum	5/6 per lb.	
„ Titanium (carbon free)	9d. per lb.	
Nickel (per ton)	£200 to £205	
Ferro Cobalt	5/3d. per lb.	

NON-FERROUS METALS.

Official Prices, November 21st.

Copper—		
Cash	£26 11 3 to £26 12 6	
Three months	£26 18 9 to £27 0 0	
Electrolytic	£29 15 0 to £30 0 0	
Best Selected Ingots, d/d Birmingham	£31 0 0	
Sheets, Hot Rolled	£58 0 0	
	Home.	Export.
Tubes, Solid Drawn (basis)	9¼d.	9¼d.
„ Brazed (basis)	9¼d.	9¼d.
Brass—		
Ingots, 70/30, d/d Birmingham	£27 0 0 to £29 0 0	
	Home.	Export.
Tubes, Solid Drawn, 2/1 Alloy	8¾d.	8¾d.
„ Brazed	10¼d.	10¼d.
Tin—		
Cash	£228 10 0 to £228 12 6	
Three months	£228 15 0 to £228 17 6	
Lead:	£10 8 9 to £10 10 0	
Spelter:	£11 16 3 to £12 1 3	
Aluminium Ingots (British)	£100	

FUELS.

SCOTLAND.

	Export.
Lanarkshire—	
(f.o.b. Grangemouth)—Navigation Unscreened	13/-
„ Glasgow—Ell	15/- to 15/6
„ „ Splint	16/6
Ayrshire—	
(f.o.b. Ports)—Steam	13/-
Fifeshire—	
(f.o.b. Methil or Burntisland)—Prime Steam	13/- to 13/3
Unscreened Navigation	12/6 to 13/-
Lothians—	
(f.o.b. Leith)—Hartley Prime	12/6 to 13/-
Secondary Steam	12/- to 12/3

ENGLAND.

Yorkshire, Manchester—	
B.S.Y. Hard Steams	18/6 to 21/6
Furnace Coke	13/- to 17/6
Northumberland, Newcastle—	
Blyth Best	14/3 to 14/6
„ Second	13/-
„ Best Small	10/6 to 11/-
Unscreened	12/6 to 13/6
Durham—	
Best Gas	14/8
Foundry Coke	18/6 to 22/6

Sheffield	Inland.
Best Hand-picked Branch	24/- to 26/-
South Yorkshire Best	21/- to 23/-
South Yorkshire Seconds	17/6 to 19/-
Rough Slacks	8/- to 9/-
Nutty Slacks	7/- to 8/6

SOUTH WALES.

Cardiff—	
Steam Coals:	
Best Admiralty Large	19/6
Seconds	19/- to 19/4½
Best Dry Large	18/9 to 19/3
Ordinaries	18/3 to 18/6
Best Bunker Smalls	13/6 to 14/-
Cargo Smalls	11/6 to 12/6
Dry Nuts	22/- to 26/-
Foundry Coke	24/- to 37/6
Furnace Coke	19/- to 21/6
Patent Fuel	21/-
Swansea—	
Anthracite Coals:	
Best Large	37/6 to 40/-
Machine-made Cobbles	41/- to 44/-
Nuts	40/- to 50/-
Beans	25/- to 30/-
Peas	19/- to 22/6
Rubbly Culm	11/6 to 12/-
Steam Coals:	
Large	17/- to 20/6

FUEL OIL.

Inland consumption; contracts in bulk.
Exclusive of Government tax of 1d. per gallon.

Ex Ocean Installation.	Per Gallon.
Furnace Oil (0·950 gravity)	3½d.
Diesel Oil	4d.

Manchester prices ¼d. per gallon extra.

French Engineering Notes.

(From our own Correspondent in Paris.)

The Industrial Outlook.

THE intention of the Government to deal particularly with economical and industrial problems in a manner designed to bring about a return to commercial liberty and a revival of private enterprise has made a good impression and has awakened hopes of an early improvement in the general situation. The change can only be effected gradually, and the State will continue to hold the reins and exercise control until the existing complications are unravelled, but the prospect of emerging from the present deadlock has produced a feeling of satisfaction which reveals how keen is the desire of all industrial and commercial classes to be freed from restrictions that have proved ruinous to enterprise of any kind. The removal of those restrictions, however, must depend upon the manner in which commercial relations with foreign countries can be restored. The announcement that the State will come to the aid of firms of good standing, where necessary, will help to revive confidence in view of the difficult situation in which some big manufacturing concerns are known to find themselves. Meanwhile, Monsieur Marquet, the late Minister of Labour and author of the five years' public works relief programme, has given a list of the undertakings already put in hand in pursuance of that scheme, including the construction of a works for the hydrogenation of coal in the Pas de Calais, but he admits that the situation has become so much worse since the plan was initiated that it would now require more than double the expenditure provided for to give practical results. In the case of railway equipment the Conseil Supérieur des Chemins de Fer has reduced expenditure for the coming year to 1699 million francs, including the amount provided for electrification and signalling under the Marquet scheme, but it has authorised the placing of orders for a number of all-metal coaches and for 230 rail motor cars. It is argued that as the railway deficit is being further increased this year by 20 per cent. it is undesirable to undertake more than what is authorised by the five years' plan of public works, except to order such rolling stock as may be strictly necessary to improve the services. The necessity of keeping a firm hold on expenditure at a time when public finance is so precarious does not improve the industrial situation, which is revealed by the growing unemployment and the further slowing down of work at factories. The official unemployment figures do not comprise all who are out of work, and the latest return of 355,000 unemployed in receipt of relief pay is believed to be much below the actual total. It is, nevertheless, high in view of the number of foreign workers who have been obliged to return to their respective countries. It is now urged that international conventions regarding the employment of foreigners should be denounced, so that employment provided by an expenditure of public funds should be reserved exclusively for French labour. The gravity of the situation explains the unanimity with which all classes are looking to the Government to inaugurate a policy that will restore industrial activity.

Harbour Works.

The credits provided for harbour works in the Budget estimates for the coming year amount to 40,490,000f. for maintenance and 53,853,000f. for new works, in addition to which 78,000,000f. have been allocated to the ports under the five years' public works relief fund. This total is less than the amount supplied during the present year by the State for harbour extensions and equipment. The reduction has been made on the ground of economy, and it is further argued that the expenditure on the ports during the past fifteen years has placed them in a position to deal satisfactorily with maritime traffic. Any further increase of the normal State allocations is therefore deemed superfluous. Exception is taken to this statement by the Association des Grands Ports Français, which affirms that the harbours have not been able to keep pace with the evolution of shipping in the direction of increased tonnage and length of ships, to the extent that wharves can no longer berth ships to their full length and a considerable total of wharf space is therefore unutilised. At the same time, the oil traffic continues to expand, and additional facilities are needed for docking tankers of bigger tonnage. Notwithstanding the reduction of credits a good deal of work that had been suspended for want of funds is being resumed, notably at Bordeaux and Marseilles, at which latter port wharf extensions are being carried out actively with a view to facilitating the North African traffic by means of the bigger ships now under construction.

Pit Props and Coal.

The objections to bilateral agreements on a strictly reciprocal basis have had no effect yet upon the agreements already entered into, and in the case of an exchange of pit props for Welsh coal the conditions laid down in London are regarded as favourable to the French pit timber trade. Until the end of this year a ton of pit props must be taken for 2 tons of coal up to a total of 40,000 tons a month, and from the beginning of 1935 the proportion will be 2 tons of props for 3 tons of coal with the same quota. Before the war the exports of pit timber from Bordeaux and other ports to South Wales amounted to 500,000 tons, and after the Armistice they rose to nearly a million tons, but following upon the British strike the exports declined to 860,000 tons, at which figure they remained fairly steady until the beginning of the slump. Last year the exports of props fell to 146,000 tons. Next year the total will be raised, under the existing agreement, to 320,000 tons. The competition from Portugal and Finland cut prices to the extent that the French could make no profit, and an adjustment of prices on a remunerative scale with South Wales coalowners has now given a more satisfactory tone to the trade. It is, however, by no means certain that this system of rigid reciprocity can continue. It limits exchanges to certain categories of goods and is detrimental to the general interest, and the failure to see that some flexibility is needed for mutual trade development is partly responsible for the trouble that has overtaken this country.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

TURBINE MACHINERY.

417,100. March 13th, 1934.—TURBINE-DRIVEN CENTRIFUGAL PUMPS, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2.

It is claimed that this turbo-feed pump can be easily erected and dismantled. The casing is not divided horizontally. The

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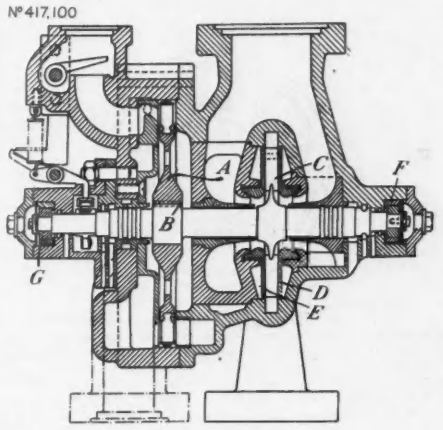

turbine disc A is fixed on its shaft by the round keys B. "The blades of the pump wheel C are fitted into the boss of the wheel, made in one piece with the shaft, and are closed laterally by the two covering discs D and E against the pressure chambers of the device." There are only two main bearings F and G.—*September 27th*, 1934.

SWITCHGEAR.

417,214. June 26th, 1933.—GAS BLAST ELECTRIC SWITCHES, *International General Electric Company, Incorporated, of 120, Broadway, New York, U.S.A.*

According to this invention, the control gear necessary for preparing and controlling the pressure gas used in gas blast switches forms a unitary apparatus which is physically separated and electrically isolated by a wall or protective grid from the current conducting parts of the switch and is connected with the switch only through the necessary pressure gas pipes. In this way the control gear is made accessible for attention even when the switch is carrying current. A is the pressure gas container. Directly on it are placed the valves and controlling electro-magnets, which are enclosed by a box B. Mounted on this is the motor compressor C. All these parts form together a unitary control gear which is constructed alone independently of the switch C^1. The control gear is connected with the switch

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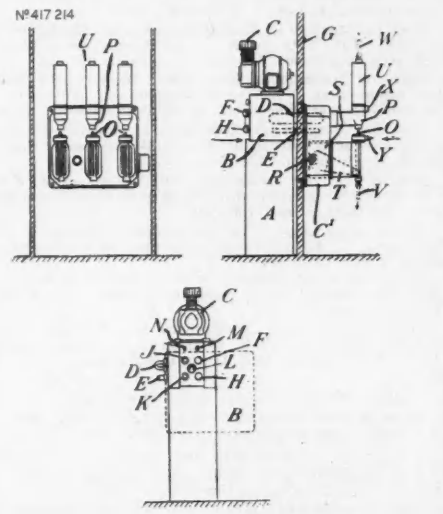


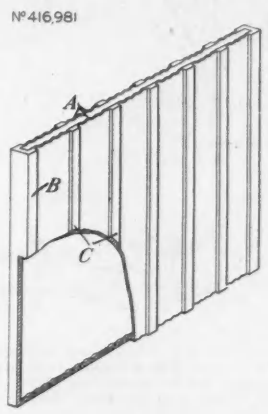
by means of the pressure gas pipes D and E for switching off and on and is separated therefrom by means of a solid wall G or a sheet of wire gauze. On the box B which encloses the valves and electro-magnets there is the pull knob F for the switching-on magnet, the pull knob H for the switching-off magnet, the pertinent signal lamps J and K, the pressure gauge L, the switch M for the compressor B and the switch N for controlling all the signalling lamps. The pressure gas switch C^1 is one in which the separating part is visible in the switched-off position, O being the point of the movable contact, and P the stationary hollow contact. The shaft R common to the three switch poles is worked by a pressure gas piston, the cylinder S of which is indicated by dotted lines. The shaft R acts on the movable contacts by means of the lever T, also indicated by dotted lines. Above the fixed contacts P there is the silencer U. The conductor connections may be clamped either at V and W or at X and Y.—*October 1st*, 1934.

BATTERIES AND ACCUMULATORS.

416,981. March 24th, 1933.—ELECTRIC STORAGE BATTERIES, Joseph Lucas, Ltd., of Great King-street, Birmingham; and Herbert Edmund Clarke, of the Company's address.

This invention has for its object to provide improved means for preventing loss of active material which may become loosened or detached from battery plates after the battery has been in use. The sides A of the envelope are made from two thin sheets of threaded rubber. This is a porous material, which is made from cotton or other threads embedded in rubber, and is used at present in the manufacture of battery plate separators. The two sheets are spaced apart in any convenient manner and are united along three of their edges to form an envelope into which a plate can be inserted through the open edge of the envelope. The lower edge of the envelope may be provided with apertures through which feet or projections on the plates can pass, but this is not an essential feature. The spacing of the sheets can be effected by threaded rubber or other strips B,

Nº 416,981



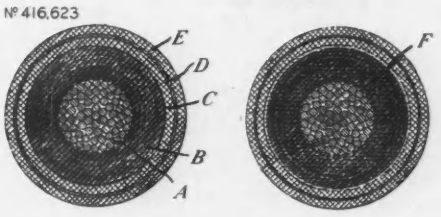
the whole being united (as by vulcanising) to form a strong envelope. Each plate of the battery is contained in an envelope as above described, and by means of the envelope the falling away from the plate of active material which is loosened by the electrolytic action or mechanical vibration is obviated, this effect being obtained without interfering with the necessary free diffusion of acid through the sheets forming the two sides of the envelope. Preferably one or each side of the sheets from which the sides of the envelope are made is provided with ribs C to allow a free acid space either between the faces of adjacent envelopes or between the inner surfaces of the envelopes and the plates, or both.—*September 24th*, 1934.

TRANSMISSION OF POWER.

416,623. December 21st, 1933.—MANUFACTURE OF ELECTRIC CABLES, The Okonite-Callender Cable Company Incorporated, of Paterson, New Jersey, U.S.

Improvements in the manufacture of electric cables having insulation impregnated with a liquid or semi-liquid material, for example, paper impregnated with oil or compound, are described in this specification. A designates the conductor of the cable, which is of the solid stranded type. This conductor is insulated by insulation B, which may be paper tape. In the process of making the cable a lead sheath or casing C is extruded or otherwise applied about the insulation B. About the sheath or lead casing C extensible material, such as canvas D, is applied in the form of a tape wound spirally about the sheath C. On the outside of the canvas D a sheath E of lead

Nº 416,623



or other suitable metal is provided. Before the cable is placed in operation the sheath or casing C is expanded a predetermined amount to the extent permitted by the canvas D or other extensible material employed, so as to leave an annular space or reservoir of uniform cross section F between the insulating envelope B and the inner wall of the sheath or casing C. This expansion of the sheath C may be accomplished during the impregnating operation, the impregnating fluid, such as oil, being introduced under sufficient pressure to cause the sheath or casing C to expand to the extent above indicated. As mentioned, this will provide a space or reservoir F between the insulation B and the inner wall of the sheath C, this space serving as a reservoir for insulating fluid, such as oil, with which it is kept filled, this insulating fluid being kept under high pressure at all times.—*September 18th*, 1934.

417,193. March 31st, 1933.—FLUID CLUTCHES, J. Stone and Co., Ltd., Deptford, and E. C. Hatcher, Instow, Woodside-road, Northwood, Middlesex.

This clutch is of the centrifugal type in which the driving shaft A transmits its force to the driven member B gradually as it picks up speed. The driver is equipped with three vanes C, which are restrained from flying outward by a garter spring

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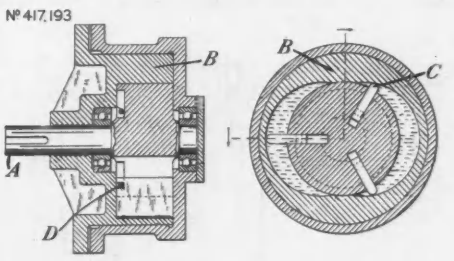

D. They work in two fluid-filled, crescent-shaped chambers in the driven member, and at low speeds transmit no torque, as they are retracted by the spring. At full speed the vanes are projected outward by centrifugal force, to bear against the walls of the crescent-shaped chambers, and a direct drive is effected through the fluid. The specification includes a variety of elaborations.—*October 1st*, 1934.

BUILDING.

416,536. August 17th, 1933.—CONCRETE PUMPS, E. Handl, 34, Enterpestraat, Amsterdam, The Netherlands.

This concrete pump aims at avoiding valves in the suction and discharge, which might be clogged with the aggregate. The

concrete is poured into the hopper A, which feeds the pump barrel B, and is forced forward by the plunger C. In the discharge D there is another plunger E that reciprocates in unison with the main plunger and a "conical stowing member" F. The result is that when the main plunger is forced down the

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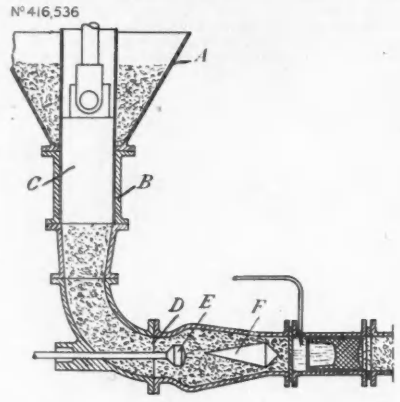

concrete is moved forward, but on the return stroke it packs up against the cone and leaves a void for a fresh charge. It will be noted that there are no tight-fitting valves, and it is claimed that with very massive concretes the plunger E may be omitted. —*September 17th*, 1934.

MISCELLANEOUS.

416,510. March 17th, 1933.—Methods of and Means for Supporting Electric Discharge Devices, The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C.2, and James Horace Taylor, of "Clovelly," Dalkeith-avenue, Bilton, Rugby.

An object of this invention is to provide a simple and inexpensive method of mounting thermionic valves and other discharge devices. For large thermionic valves an expensive holder is required which necessitates the use of expensive and accurately made jigs and tools to ensure that the pins or terminals are secured in their correct relative positions, and a further object of the invention is to eliminate the use of these tools, so reducing the cost of manufacture. A represents the base

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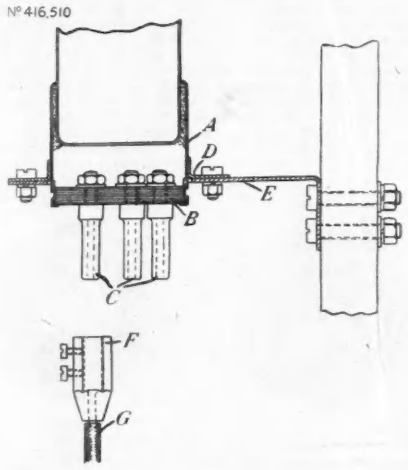

cap of a thermionic discharge device to the lower end of which an insulating plate B is secured, through which the terminals or pins C of the device project. Secured to the base near its lower end is an annular flange D, which engages and is secured to a support or plate E having an aperture sufficiently large for the lower end of the base cap to pass through. To connect the pins of the device to their circuits, thimbles F are provided, and the conductors G may be soldered or otherwise secured to them, these thimbles being either a good sliding fit on the pins or provided with screws as shown in order to ensure good electrical connection between the thimbles and the pin. The thimbles and pins may be suitably marked so that wrong connections may be obviated.—*September 17th*, 1934

416,805. May 5th, 1933.—Steam Traps, Hopkinsons, Ltd., Britannia Works, Huddersfield, R. L. Brown, and J. A, Eastwood.

This invention relates to steam traps of the float or the bucket type, and has for its object to increase their reliability and efficiency. The bucket A is pivotally connected to a crank arm B upon a horizontal spindle C, having a further small

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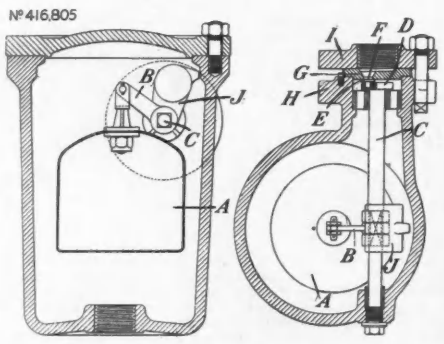
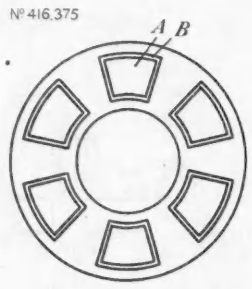


crank arm D thereon, by which the delivery valve E is moved to close and open the throughway aperture F in the seat G, which is clamped between a flange H on the steam trap casing and a companion flange I for connection to the discharge pipe. A weighted arm J is secured upon the horizontal spindle C, so that it moves therewith, its angular location being such that it is at one side of its centra and uppermost position when the valve is closed, which is the position shown, and at the other side of that position when the valve E is open. The weight exerts its maximum downward effort when the bucket is in its bottom position. The bucket has therefore to acquire maximum buoyancy by the discharge of liquid therefrom before it can start to rise. The resistance exerted by the weight to the upward movement of the bucket gradually decreases as the bucket rises until, when the bucket is effecting the final closure of the valve E, there is no resistance by the weight to the bucket movement. The weight is, in fact, then slightly assisting the bucket.—*September 21st*, 1934.

416,375. January 11th, 1933.—Mercury Arc Rectifiers, The General Electric Company, Ltd., of Magnet House, Kingsway, London, W.C.2, and Enrico Gallizia, of The General Electric Company, Ltd., Engineering Works, Witton, Birmingham.

The safe current rating of a converter, such as a mercury arc converter, is determined largely by the current density at the anodes and the temperature which the anodes attain when the converter operates under full-load conditions, and an object of this invention is the provision of anode arrangements having improved load-temperature characteristics, so that for a given rating the size of the converter may be reduced or for a given

Nº 416,375



size of converter the rating may be increased. According to the invention, the peripheral outline of the end surface of each anode is of a non-circular shape adapted to give an area of end surface relatively large for the size of the container for the purpose of efficient utilisation of the latter. One or more sides of the anodes may be parallel or approximately parallel to the adjacent arrange ments. As shown, the anodes A are of sector shape in cross section, and are surrounded by similarly shaped shields B. Instead of being of sector shape the anodes and their similarly shaped shields may be of trapezoidal, square, rectangular, or of similar cross sectional shape.—*September 11th*, 1934.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

Chadwick Public Lectures.—At Royal Soc. of Arts, John-street, Adelphi, W.C.2. "Good Housing: The Basis of Individual and Social Health," Sir Raymond Unwin. 5.30 p.m.

Chemical Engineering Group.—Burlington House, W.1. "The Chemical Engineering Aspect of Low-temperature Carbonisation," Colonel W. A. Bristow. 6 p.m.

Inst. of Electrical Engineers: N. Eastern Students' Section.—Tilley's Grand Assembly Rooms, Barras Bridge, Newcastle-upon-Tyne. Annual dance. 8 p.m. to 1 a.m.

Inst. of Mechanical Engineers.—Storey's-gate, S.W.1, Informal meeting. "The Overseas Engineering Representative, His Problems and Difficulties," Mr. B. W. Bagshawe. 7 p.m.

Inst. of Structural Engineers: Midland Counties Branch.—James Watt Memorial Inst., Birmingham. "Cranes," Mr. B. W. Thompson. 6.30 p.m.

Junior Inst. of Engineers.—39, Victoria-street, S.W.1. "Notes and Hints on the Application of Ball and Roller Bearings," Mr. R. O. Baird. 7.30 p.m.

Manchester Assoc. of Engineers.—Engineers' Club, Manchester. "Lifting Tackle: Its Care and Maintenance," Mr. A. Taylor. 7.15 p.m.

Royal Inst. of Great Britain.—21, Albemarle-street, W.1. Discourse, "Heavy Water in Chemistry," Professor M. Polanyi. 9 p.m.

Stratfordians' Assoc.—Abercorn Rooms, Great Eastern Hotel, Liverpool-street, E.C. Reunion dinner. Particulars from Mr. A. W. Headley, C.M.E. Dept., L.N.E. Railway, Stratford, E.15.

TO-DAY AND SATURDAY, NOV. 24TH.

Machine Tool Exhibition.—Olympia, W. Daily, 10.30 a.m. to 8.30 p.m.; Saturday, 10 a.m. to 10 p.m.

SATURDAY, NOV. 24TH.

Inst. of Mechanical Engineers: London Graduates' Section.—Visit to Beckton Gasworks.

Inst. of Civil Engineers: Students.—Afternoon visit to the reconstruction works, Bank of England.

MONDAY, NOV. 26TH.

Bradford Engineering Soc.—Technical College, Bradford. "The Lubrication of Prime Movers," Mr. A. J. Walker. 7.30 p.m.

Inst. of Electrical Engineers: N. Eastern Centre.—Armstrong College, Newcastle-upon-Tyne. "Hydro-electric Development in Great Britain, with Special Reference to the Works of the Grampian Electricity Supply Company," Messrs. A. S. Valentine and E. M. Bergstrom. 7 p.m.

Royal Soc. of Arts.—John-street, Adelphi, W.C.2. Cantor Lecture, "Modern Spectroscopy," Lecture II, Dr. Herbert Dingle. 8 p.m.

TUESDAY, NOV. 27TH.

Chelsea Polytechnic, S.W.3.—Prize distribution and also diplomas and certificates, by Prof. W. G. Constable. 8.30 p.m.

Inst. of Electrical Engineers: Scottish Centre.—Grosvenor Restaurant, Gordon-street, Glasgow, C.2. Annual dinner; reception, 6.30 for 7 p.m.

Inst. of Electrical Engineers: S. Midland Students.—James Watt Memorial Inst., Birmingham. The Students' Lecture, "Modern Street Lighting," Mr. C. C. Paterson. 7 p.m.

Sheffield Metallurgical Assoc.—198, West-street, Sheffield, 1. "Abnormality as Judged by the McQuaid-Elin Test," Mr. T. Hunter. 7.30 p.m.

WEDNESDAY, NOV. 28TH.

Inst. of Automobile Engineers.—Queen's Hotel, Leeds. "The Problem of Variable Transmission," Mr. J. Bedford. 7.15 p.m.

Inst. of Automobile Engineers.—Engineers' Club, Manchester. "The Utilisation Aesthetics of Automobile Body Design," Mr. W. O. Kennington. 7 p.m.

Inst. of Civil Engineers.—Great George-street, S.W. 1. Paper to be further discussed, "The Evolution of Various Types of Crushers for Stone and Ore, and the Characteristics of Rocks as Affecting Abrasion in Crushing Machinery," Messrs. W. T. W. Miller and R. J. Sarjant. 6 p.m.

Inst. of Civil Engineers: Yorkshire Assoc.—Grand Hotel, Sheffield. "The Ryburn Dam," Mr. F. L. Pawley. 7.30 p.m.

Inst. of Fuel.—At Chemical Soc., Burlington House, Piccadilly, W.1. "Nature of the Processes of Oil Cracking, Water Gas Carburetting and Hydrogenation," Prof. M. W. Travers, F.R.S. 6 p.m.

Inst. of Welding Engineers: N. Western Branch.—College of Technology, Sackville-street, Manchester. "The Fundamental of Electric Welding," Dr. J. H. Paterson. 7.30 p.m.

Royal Soc. of Arts.—John-street, Adelphi, W.C.2. "Pottery," Mr. Gordon M. Forsyth. 8 p.m.

Societe des Ingenieurs Civils de France: British Section.—At Inst. of Mechanical Engineers, Storey's-gate, S.W.1. "The Mineral Resources of Yugoslavia," Mr. H. K. Scott. 6 p.m.

THURSDAY, NOV. 29TH.

Glasgow University Engineering Soc.—Engineering Dept., Glasgow University, W.2. "Light, High-speed, Two-stroke Engines," Mr. J. W. Robertson. 7.30 p.m.

Inst. of Locomotive Engineers.—At Inst. of Mechanical Engineers, Storey's-gate, S.W.1. "Ejectors," Mr. Conway Arnold. 6 p.m.

Inst. of Metals.—James Watt Memorial Inst., Birmingham. "Directionality in some Annealed Non-ferrous Alloys," Mr. R. G. Johnston. 7 p.m.

Royal Aeronautical Soc.—At Royal Soc. of Arts, John-street, Adelphi, W.C.2. "Engine Research," Capt. A. G. Forsyth. 6.30 p.m.

FRIDAY, NOV. 30TH.

Inst. of Electrical Engineers: S. Midlands.—Grand Hotel, Birmingham. Annual dinner. 6.30 for 7 p.m.

Inst. of Mechanical Engineers.—Storey's-gate, S.W.1. Thomas Lowe Gray Lecture, "A Survey of Ships and Engines," Mr. Loughnan St. L. Pendred. 6 p.m.

Inst. of Metals: London Local Section.—Thames House, Millbank, S.W.1. Supper-dance. 7.30 p.m. to midnight.

Inst. of Professional Civil Servants.—At Royal Soc. of Arts, John-street, Adelphi, W.C.2. Lecture by Mr. A. Keiller. 5 for 5.30 p.m.

N. East Coast Inst. of Engineers and Shipbuilders.—At Mining Inst., Newcastle-upon-Tyne. "The Trend of Destroyer Design," Mr. E. Leslie Champness. 6 p.m.

CONTRACTS AND ORDERS.

The Editor is always happy to print short announcements of contracts and orders in this column provided they are sent to him in time to have news value and that they are likely to interest readers.

Merryweather and Sons have received the order for the whole of the fire pumping equipment to be installed on the new London fire boat "Massey Shaw." The installation will include two Merryweather multi-stage centrifugal pumps, each capable of delivering up to 2100 gallons per minute, and the deck fittings will comprise four salvage suction inlets, two deck discharge boxes, each having four delivery valves, and one large mechanically operated nozzle, technically known as a monitor.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

Mr. S. McLean has resigned his position with Hick, Hargreaves and Co., Ltd., of Bolton, to take up an appointment with David Brown and Sons (Huddersfield), Ltd., as the firm's district manager in London.

Mr. B. P. Fisher Deane, A.M.I.E.E., A.M.I. Mech. E., 17, Victoria-street, Westminster, S.W.1, late London representative of Sanderson Bros. and Newbould, of Sheffield, is now representing Mark L. Sykes, Ltd., of Leeds, and A. R. Heathcote and Co., Sheffield.

The British Thomson-Houston Company, Ltd., Rugby, informs us that Mr. J. S. Ramsden, M.I.E.E., and Mr. F. Samuelson, M.I. Mech. E., M.I.E.E., have been appointed directors of the company. Mr. Ramsden is industrial sales manager and Mr. Samuelson is engineer and manager of the turbine factory.

The Iron and Steel Institute.—The Council of the Iron and Steel Institute has elected W. H. Hatfield, D.Met., and Sir William J. Larke, K.B.E., to be Vice-Presidents; and Lieut.-Col. Sir Maurice H. L. Bell, Bt., C.M.G., to be an Honorary Vice-President.

Royal Scottish Museum.—Mr. Thomas Rowatt, M.I. Mech. E., has been appointed Director of the Royal Scottish Museum, Edinburgh, by the Secretary of State for Scotland, in succession to the late Mr. E. Ward. On the retirement of Dr. A. Galt in 1921 Mr. Rowatt was appointed Keeper of the Technological Department, with which he has been associated from its foundation.

The Institute of Transport.—The Council of the Institute of Transport announces that clauses 8 and 14 (c) of the Institute examination regulations, permitting in certain cases election to studentship and graduateship without examination, will expire on September 30th, 1935. Clause 14 (c) will not be renewed and after September 30th next, therefore, admission to graduateship will be by examination only. The present clause 8 will be replaced as from October 1st, 1935, by the following:—"The Council may elect to studentship a person who is at least twenty-one years of age, produces evidence of having attained an educational standard equivalent to that ordinarily required of students and is engaged and has had not less than a year's service satisfactory to the Council with one or more of the principal transport undertakings or other organisations recognised as such by the Council."

A Seven-Day Journal

The Water Grid.

To those engineers and others whose experience entitles them to express an opinion, the notion of a "water grid" on the analogy of the electricity grid is, says the Executive Committee in its latest report to the British Waterworks Association, an absurdity. The problems of water supply, although having naturally a "national" character, are essentially local, or rather regional, being framed upon the natural watershed(s), as distinct from the artificial boundaries of parish and county. With reference to water supplies in scattered or sparsely populated areas, it has to be observed, says the report, that at the date of the 1931 Census the population of the rural districts in England and Wales was approximately 8,000,000 persons, being equal to one-fifth of the total population of those two countries, or about the same as that of Greater London. No statistics are available as to the number of the population in rural areas enjoying adequate water supply and sewerage services, but admittedly there must be a considerable number where the sanitary conditions fall short of present-day standards. The recent persistent drought has incidentally accelerated consideration of the inter-related problem of sewage disposal and rivers pollution prevention which was receiving increased attention before the advent of the drought. With the assistance afforded on a co-operative basis between the district, the county, and the State, the scarcity of water in rural areas, largely due to the local indifference of rural communities until they were told that they had a grievance, and the consequent unsatisfactory state of affairs in this respect, should be materially improved without the aid of a national water board or water grid.

The Brussels Exhibition, 1935.

On Thursday of last week the roof of a lateral gallery of the Grand Palais in course of construction at the Brussels Exhibition to be held next year collapsed and killed nine workmen and injured more than twenty others. The gallery had a length of 164ft. and a width of 131ft. The wreckage is so complete that it will probably be difficult to do more than surmise the cause of the disaster, but without implying that the design and method of construction may have had anything to do with the collapse, it may, nevertheless, be remarked that the plans of the Grand Palais follow the lines of modern exhibition design which aims at suppressing intermediate roof supports. This method has introduced methods of roof construction which have been applied successfully to structures of greater span than the gallery which collapsed. Another regrettable incident is the withdrawal of Germany from the Brussels Exhibition after that country had secured space for a building which would have surpassed in size all other national pavilions. The construction of the German pavilion was well advanced when work upon it was stopped, and Germany has now declared that she will be unable to participate in the Exhibition on account of financial difficulties. The Belgians will not allow the serious shocks they have sustained to interfere with the Exhibition's success. The partial collapse of the Grand Palais will certainly be made good in time for the opening six months hence, and it is believed that the participation of Great Britain, France, Italy, and other countries will fully make up for the German defection.

Research on Electro-Deposition of Metals.

Research work of national importance on the electro-deposition of metals is threatened with curtailment, and an appeal is being made to industry for co-operation in maintaining this essential work. The work includes electro-deposition of nickel and chromium, the protection from corrosion of aluminium and its alloys by the electro-deposition of zinc, cadmium, &c., and fundamental questions, such as the occurrence of stress in deposits and the mechanism of adhesion. The cost has been very considerable, and has up to this time been borne almost exclusively by the Exchequer. The D.S.I.R. now takes the view that research of this kind, carried out for the benefit of industry, should be maintained by the branches of industry concerned. Consequently, the work can continue only if it is adequately supported by industry. It would be a matter for grave regret if suspension or curtailment became necessary, since the work has now reached a stage at which further important practical results may be expected. Furthermore, closing down would entail the dispersal of experienced staff having valuable specialised knowledge of the subject. It is now proposed that this work should be taken over entirely by the British Non-Ferrous Metals Research Association. In this way Government support of the research would not cease, but would be dependent on the funds forthcoming from industry. The scheme in view has the full approval of the Department of Scientific and Industrial Research. The minimum expenditure necessary is £1000 per annum, and it is hoped that sufficient funds will be provided for this purpose by those sections of the industry concerned with electro-deposition. All those who are interested are asked to write to the Secretary, British Non-Ferrous Metals Research Association, Regnart Buildings, Euston-street, London, N.W.1, for further particulars.

French Battleships.

Work upon the sister ship of the "Dunkerque," of 26,600 tons, to be named the "Strasbourg," was started on Monday at the Penhoët shipyard. The "Dunkerque" is under construction in the arsenal of Brest, and the new ship is being built in a private yard with a view to helping the shipbuilding industry, and more especially to accelerating its completion at a time when a line of modern battleships is regarded as of paramount importance. Since the "Dunkerque" was put on the stocks in reply to the German battle-cruisers the policy of naval construction in Germany is declared in France to have undergone a change in the direction of ignoring treaty restrictions, and it is affirmed that the 10,000-ton limit will be exceeded by ships of the battleship category evolved from the type of battle-cruisers already launched. The situation is regarded by the French as too serious to admit of any delay in constructing their second battleship, and work upon both ships is to be pushed forward as rapidly as possible.

Electricity (Supply) Bill.

The Federation of British Industries views with considerable alarm the Electricity (Supply) Bill, 1934, which, it believes, would overthrow the principle that the functions of the bodies set up by Parliament for the development of electricity supply—the Electricity Commissioners and the Central Electricity Board—should be for promoting and co-ordinating the supply of electricity through existing undertakings and not for direct trading purposes. In a letter to the Minister of Transport, it says that the Bill upsets this basic position in that it provides for direct trading to consumers, which, although limited in the present Bill to railways and railway works, will, by establishing a precedent, lead eventually to a wide semi-state trading without any direct commercial control or economic safeguard. One of the resulting dangers of granting even limited trading powers to the Board, says the F.B.I., is that it is most likely to lead to an unfavourable reaction on all other classes of consumers, particularly industrial. Ample facilities exist for any railway undertaking to obtain its supplies from authorised undertakers, as shown by past and present experience, and as the Bill is apparently not called for by the railway companies, mine owners and others who have railway powers, the reason for its introduction is not obvious. The Federation suggests that a Bill of such great consequence technically and economically can hardly be dealt with adequately under normal Parliamentary procedure, and therefore should be subject matter for examination by a Select Committee, which would allow of the merits and demerits of the case being fully examined.

Industrial Reorganisation.

On Thursday, November 22nd, Lord Melchett introduced into the House of Lords a measure called the Industrial Reorganisation (Enabling) Bill. The object of the Bill is to provide for the self-government of industries by enabling the majority of producers in an industry, notwithstanding the opposition of a small minority, to introduce and cause to be enforced schemes for the reorganisation of the whole or part of that industry with the general object of promoting greater efficiency, eliminating wasteful competition, and of facilitating the production, manufacture, and supply of the products of the industry. Before any such scheme becomes effective it is to be subjected to proper inquiry by a specially appointed National Industrial Council for the purpose of ascertaining that it is in the public interest, that it relates to an industry or part of an industry which is fit for independent reorganisation, that it provides for adequate consultation with interested persons or bodies of persons, that it can be carried into effect without detriment to other industries, and that it provides adequately for the future expansion of the industry to which it relates. In addition, it must receive the support of at least a three-quarters vote of the persons voting at a poll of the industry to which the scheme relates.

The Transmission Section of the Inst. E.E.

A conversazione and supper dance, organised by the Transmission Section of the Institution of Electrical Engineers, was held on Friday, November 23rd, at the Georgian Restaurant of Harrods, Ltd., Knightsbridge, S.W.1. Mr. Borlase Matthews, Chairman of the Section, who delivered the inaugural address at the first meeting of the Section on Wednesday, November 21st, presided at the supper, at which about 245 members and visitors were present. Owing to the absence of speeches and the excellence of the arrangements, which included the provision of fourteen electrical transmission exhibits, everyone present spent an exceptionally pleasant evening. The Transmission Section was set up by the Council in July of this year for the reading and discussion of papers on the design, manufacture, construction, maintenance, and operation of overhead and underground transmission lines. It is being conducted in the same way as the older Wireless, and Meter and Instrument Sections, and as far as possible takes the place of the Overhead Lines Association, which, as the result of discussion between it and the Institution, and a ballot of its members, has been dissolved. Members of the Association who were already also members of the Institution automatically became members of the Transmission Section. Members of any class of the Institution may apply for membership of the Section, and provided they satisfy the Section Committee that they are actively engaged in the study, design, manufacture, construction, maintenance, and/or operation of transmission and distribution lines, will be duly elected.

Palmers Hebburn.

Considerable satisfaction is felt on the North-East Coast area at the registration of a private company styled Palmers Hebburn Company, which will take over the ship and engine-repairing and constructional steel work interests of Palmer's Shipbuilding and Iron Company, Ltd., at Hebburn-on-Tyne. As foreshadowed in our Journal note of May 25th last, the chairman of the new company is Mr. F. C. Pyman, the managing director of William Gray and Co., Ltd., of West Hartlepool, while Colonel D. R. MacDonald, the late general manager of Palmers, is a director, and Mr. E. L. Champness the managing director. Work has already been begun on improvements connected with the general facilities available for the work of the new company, and the dredging of the whole of the 1300ft. frontage of the Hebburn premises has been completed in order to facilitate the carrying out of repairs afloat. Throughout the summer several large vessels have been dealt with for repairs and the work has included the re-riveting of the whole of the bottom of the South American oil tanker "Juvenal." Although no new construction work will be undertaken by the new company, the large repair and reconstruction jobs for which the works were designed and laid out will, it is hoped, apart from ordinary ship repairs, give employment to many of the company's former workpeople in a district in which employment is so badly needed.

Air Subsidies.

On Tuesday last, an important conference was held with the Prime Minister and the Minister for Air by the Conservative Parliamentary Air Committee, led by Rear-Admiral Sir Murray Sueter. It is understood that the delegation urged the Government to adopt a programme which the Conservative Parliamentary Air Committee recently drew up. That programme included the appointment of an additional Under-Secretary for Civil Aviation and an increased subsidy to permit development of ground resources at home and abroad, and consequent increases of the speed and frequency of Imperial services; also the adoption of night flying. The interview lasted for more than an hour. It is understood the Ministers plainly intimated that more money was to be allocated to civil aviation in future.

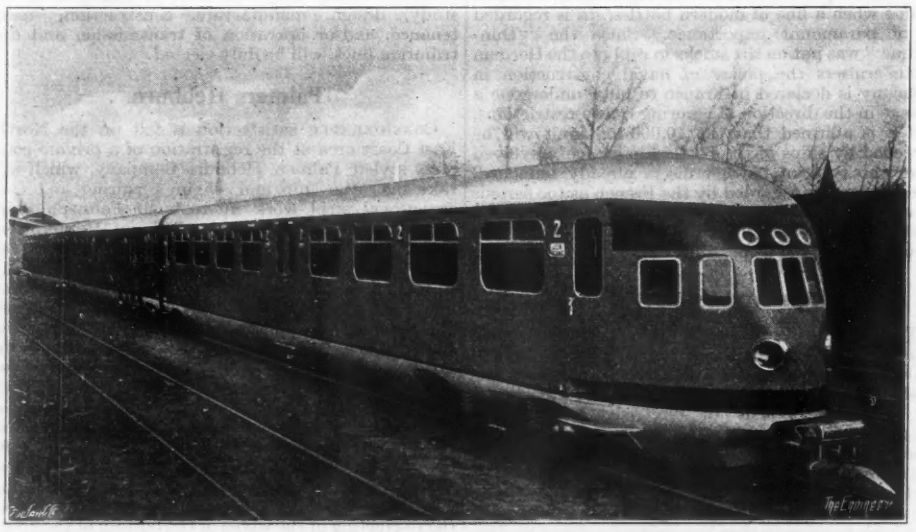
The Mechanical Testing of Timber.

The report of the Committee appointed in 1929, under the chairmanship of Sir Alfred Ewing, to review the testing of timber for strength and elasticity has recently been issued by the Department of Scientific and Industrial Research. It contains some interesting recommendations with regard to timber tests and the manner in which they should be carried out. A new method of preparing specimens for tensile tests along the grain is described. It eliminates the accidental bending of specimens during manufacture, and at the same time allows them to be prepared, if necessary, with hand tools. As regards tension perpendicular to the grain and the cleavage test, the latter test is recommended as one which indicates the relative liability of timber to split. Turned test pieces can be employed for a true tensile test. For testing compression along the grain, square rectangular blocks are suggested for approximate grading tests, but turned bobbins for an accurate determination of compression strength. For compression tests perpendicular to the grain, 2in. cubical blocks uniformly loaded on the whole of a pair of opposite faces are recommended for general use. Shearing along the grain may be carried out with a simple cube loaded diagonally and a modified form of apparatus for this test is described. The central loading test is to be preferred for the static bending test, for convenience in testing. Impact bending tests and notched bar tests are recommended for adoption in special cases. It is proposed that the hardness test should be retained and should be re-named the Janka indentation test. With regard to abrasion, the Committee suggests that a test of this nature is apparently much needed for the selection of timbers for flooring and for other purposes where resistance to wear is the most important property.

Progress in Oil Engine Traction.

(From a Correspondent.)

THE news that the thirty-five Maybach-engined trains on the Netherlands Railways have been withdrawn from service after barely four months' operation is practically the only discouraging note in the record of the development of the oil engine as applied to railway traction within the past twelve months, but need not be viewed too pessimistically. The troubles which have been experienced were, perhaps, due in the first place to the rapidity with which the whole order was conceived and executed, and to an erroneous selection of the transmission characteristics.



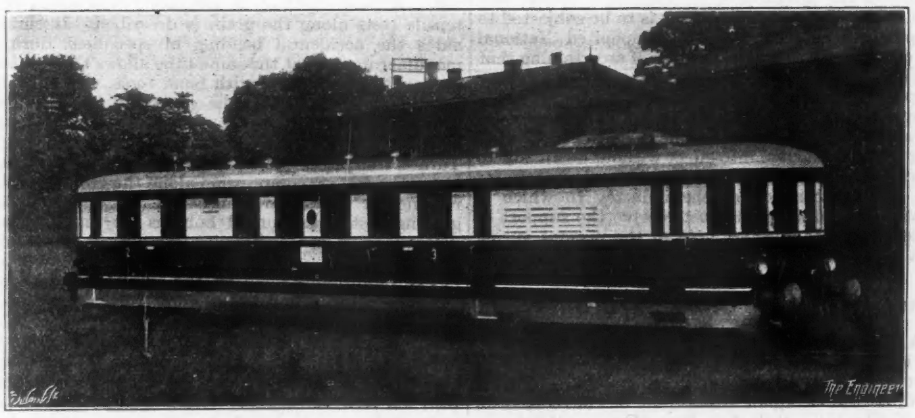
820 B.H.P. OIL-ELECTRIC TRAIN—NETHERLANDS RAILWAY

Netherlands and Germany.

It appears that in addition to the duties actually worked, necessitating the operation of the engines for appreciable periods at about 800 r.p.m. at something more than mere idling power (instead of near the rated speed of 1400 r.p.m.), some of the fuel supply pipes cracked and the joints leaked, leading to frequent air locks and variations in the fuel supply. Dirty filters also added their quota to the general misery, with the result that several pistons and a few crank shafts were broken, and in one or two cases the cylinder walls were cracked, which is more serious in the Maybach engine than in many other designs, as liners are not used. It is expected that the first train with improved characteristics and constituents will be in service again about the beginning of December.

The five trains with 400 b.h.p. Stork-Ganz engines have not yet seen any actual revenue service, as by the time they were ready some trouble had been experienced with the other units, and it was felt advisable to hold them out of traffic until the causes had been investigated. The Stork-Ganz engines have eight cylinders, with a bore of 6·69in. and a stroke of 8·65in., and develop a rated output of 400 b.h.p. at 1450 r.p.m. The engines idle at 800 r.p.m., and in the Dutch trains are arranged to run continuously at 960, 1060, 1200, 1300, or 1400 r.p.m. On test engines scale 16 lb. per b.h.p., compared with the 11 lb. of the Maybach engine, which is itself an increase of 19 per cent. on the weight of the first model as brought out about four years ago.

The prototype of the Dutch trains, the "Flying Hamburger," continues to wend its 77 m.p.h. way between Berlin and Hamburg with regularity, and although a steam train is held in readiness and has had to be substituted on certain occasions, the availability of the super-speed oil train has been something over 80 per cent. since it went into regular service in May, 1933. It is not suggested, of course, that this has been accomplished without any engine replacements. Maximum speeds vary from 100 to 102 m.p.h. on normal runs, but they are not momentary, as records exist of averages of 99–101 m.p.h. being maintained for 30 consecutive miles, and, one of them was run for 64 hours consecutively with only two short stops, the first of which was due to a fault developing in the water brake and the second to a piece of foreign matter in an atomiser. These assisted by judicious propaganda, the "Flying Hamburger" still bestrides the narrow world of railway speed like a Colossus.



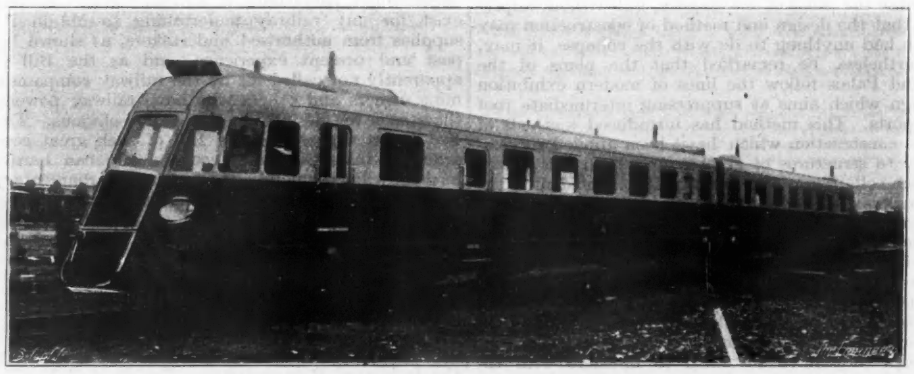
330 B.H.P. OIL-ELECTRIC RAILCAR—GERMAN STATE RAILWAY

Its performance has led to further trains being ordered, to enable a high-speed railcar service to be maintained between the principal German cities. This programme of 65–75 m.p.h. schedules will begin in 1935, but Dr. Dorpmuller, the general manager of the Reichsbahn, has stated that some years must elapse before these services can extend to the eighteen lines for which they are planned. Some of the new high-speed vehicles now being built are being raised in output from the 820 b.h.p. of the "Flying Hamburger" to 1200 b.h.p. by supercharging, and are being fitted with the Voith hydraulic drive.

In less spectacular, but possibly more paying, services, the German State Railway is introducing a host of oil railcars of 120 to 410 b.h.p. with electric and geared transmissions. Approximately 120 cars are actually in operation, and another 200 are on order for delivery by the end of 1935. The engines are of the Maybach, M.A.N., Daimler-Benz, and Mercédès-Benz types. Large orders have also been placed for low-power loco-tractors for shunting service in big yards and at small out stations. The favourite engine for these vehicles is the Deutz, but other makes are in use.

France.

High speed as a paying proposition has been recognised in France probably more than in any other country. Apart from the Nord streamlined trains, which now maintain two up and two down start-to-stop schedules in excess of 60 m.p.h. on the runs between Paris, Lille, and Tourcoing, and the new 500 b.h.p. articulated Renault trains, which on October 6th commenced a fast service on the Etat between Paris and Caen, none of the 120 odd French oil-engined railcars has a maximum designed speed below 56 m.p.h., in contrast to the numerous cars in Germany, Hungary, and elsewhere which are limited to 40 m.p.h. Yet almost 50 per cent. of the French stud is made up of vehicles engaged in local or short-distance traffic. More streamlined Renaults are being built for the P.L.M., and it is anticipated that they will operate the long-mooted 100 km.p.h. service between Paris and the Riviera. Over fifty of the standard double-bogie 250 b.h.p. Renault cars are at work, and regularly run at speeds of 70–75 m.p.h. on such lines as Lyon–Dijon, Lyon–Grenoble, Nantes–Tours. After this, the most popular vehicle is the double-engined De Dietrich, with two 105 b.h.p. two-cycle opposed-piston engines of the Junkers type. Mechanical transmission for railcars is universal in France, with the exception



500 B.H.P. RENAULT OIL-MECHANICAL TRAIN—FRENCH STATE RAILWAYS

of one car on the P.L.M. and the two 820 b.h.p. trains on the Nord.

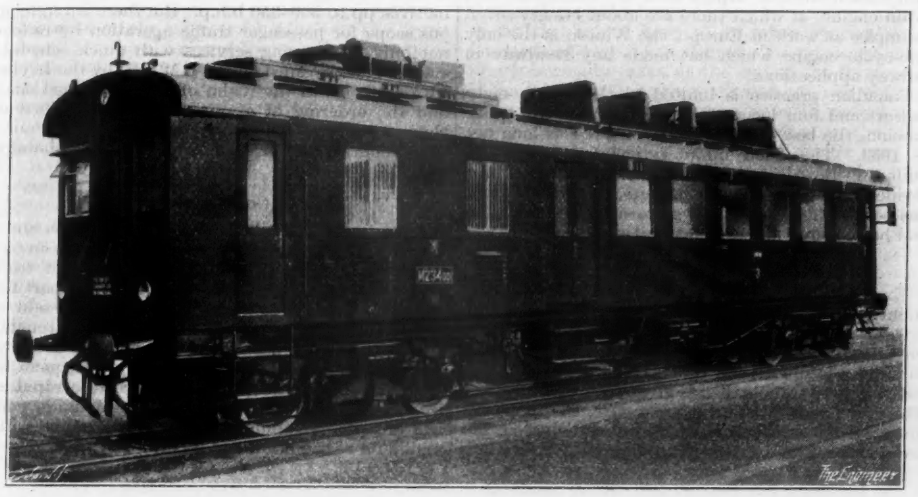
In the locomotive line France can boast only of the four heavy shunters on the P.L.M., a handful of the standard 240 b.h.p. shunters of O.C.E.M. design, and the 800 B.H.P. unit on the Ceinture. There are, however, numerous small loco-tractors. The P.L.M. has put into service on its Algerian system a 920 b.h.p. express oil-electric locomotive and a 750 b.h.p. mixed-traffic machine. The most momentous news regarding the P.L.M. is that the department of *materiel et traction* is considering tenders for one or two main line locomotives of 3500–4000 b.h.p. for service on the French system.

Czechoslovakia and Hungary.

The largest user of railcars on the Continent is the Czechoslovak State Railways, but in this instance the majority of the vehicles are propelled by petrol engines. Approximately 250 cars are in service, of which only 10 per cent. are fitted with oil engines, but much of the stock now under construction is of the oil-engined type. The latter system of traction has recently been extended to fast traffic, the most prominent example of which is the "Blue Arrow," a 300 b.h.p. oil-electric car which runs between Prague and Bratislava, and is capable of a top speed of 75 m.p.h. An unusual feature of Czechoslovak practice is that a number of cars are fitted with horizontal oil engines located beneath the floor of the car, thus giving the maximum amount of space to revenue-earning purposes. The cars powered by these engines are further noteworthy for the extent

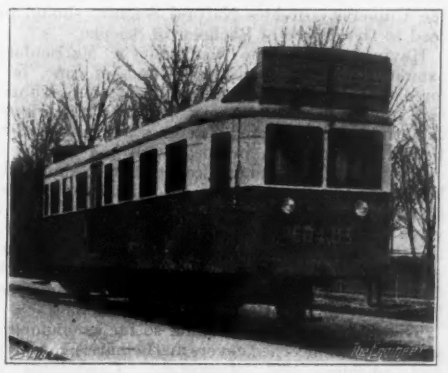
to which welding has been adopted in order to obtain a high ratio of paying load to tare weight, and a 160 b.h.p. four-wheeled vehicle seats fifty-six people on a tare weight of 17 tons.

The neighbouring country of Hungary, after extensive experience with four and six-wheeled oil-engined railcars in local traffic, is also going in for high-speed



300 B.H.P. OIL-ELECTRIC RAILCAR—CZECHOSLOVAK STATE RAILWAYS

units, and the streamlined cars recently tried on the Budapest–Hegyeshalom main line have a top speed of 75 m.p.h. It is characteristic of all the European countries which have adopted railcars that the maximum allowable speed has been raised for these vehicles compared with steam trains, although not yet as a matter of general law, each case being considered individually. In Hungary, few steam locomotives



120/150 B.H.P. OIL-MECHANICAL RAILCAR—BELGIAN NATIONAL RAILWAYS

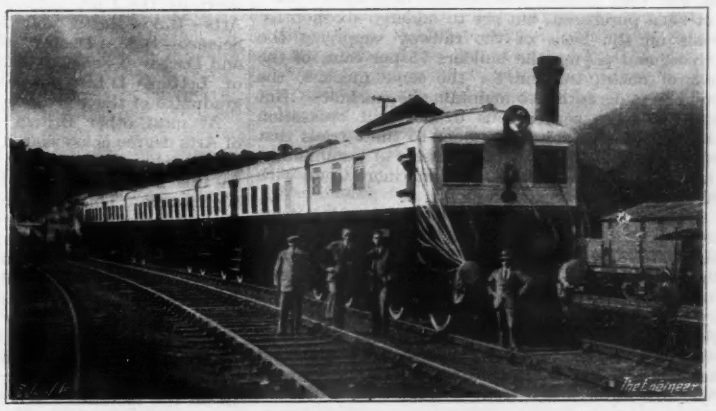
are permitted to run at more than 56 m.p.h., and in Czechoslovakia at more than 62 m.p.h.

Belgium.

Low-powered cars of the Ganz type, similar to those which have operated in Hungary for three or four years, have just been introduced on the Belgian National Railways, where the four cars placed in service from January to April last are making monthly mileages of about 2500 miles. A fifth car was on order, but was destroyed by fire at the makers' works before delivery.

The seventeen Maybach-engined cars of 175 b.h.p. are making individual mileages of 4000 per mensem, and the three cars of this type which have been in service since 1930 are credited with an aggregate mileage of 675,000, all made in stopping service. There are now twenty-six oil-engined railcars at work on the Belgian National system, and a further three are being built. It is possible that the one 410 b.h.p. streamlined car will be supplemented by others of greater power, as tenders are now being considered for ten vehicles of a generally similar type but with two engines instead of one.

Extremely interesting experiences have been obtained with the small Maybach cars. The three units built in 1930 had the usual six-cylinder engine developing 150 b.h.p. at 1300 r.p.m. About two years ago it was decided to raise the output to 175 b.h.p. by raising the speed to 1400 r.p.m., fitting aluminium pistons in place of the original cast iron units, and slightly modifying the shape of the combustion chamber. These alterations were not peculiar to the Belgian stock, but applied to the 150 b.h.p. Maybach engine in general. On the Belgian Railways fourteen new vehicles with 175 b.h.p. engines were placed in service in 1933, and the three original engines converted, and trouble at once began, principally in the pitting and scoring of the main and big-end roller bearings, which apparently would not stand up to the increased load. The faults occur at no one particular point in the races or rollers, and many of them can be seen at a distance with the naked eye; examination under a microscope is startling. The trouble has not yet been finally overcome.



450 B.H.P. OIL-ELECTRIC TRAIN—SAN PAULO RAILWAY

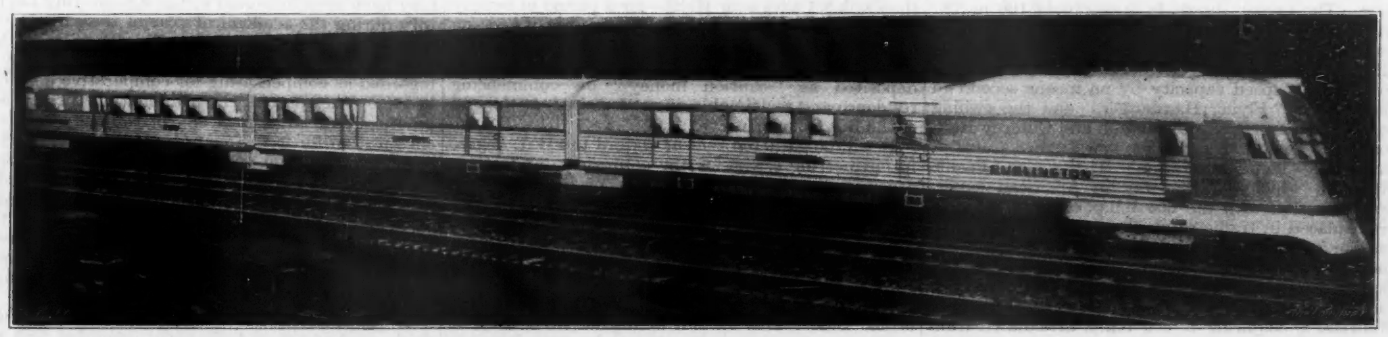
Other European Countries.

Danish railways are continuing upon the slow but sure path towards the oil-electrification of all lines except the Copenhagen suburban routes. Of the 100-odd oil-engined railway vehicles in Denmark, only one 125 b.h.p. railcar and seventeen tractors of 65/90 b.h.p. are equipped with mechanical transmission. High-speed vehicles are being introduced in the shape of four triple-articulated trains with Frichs engines having a total output of 1100 b.h.p. The ten 480 b.h.p. double-bogie railcars, with a maximum speed of 75 m.p.h., which were delivered in the early part of this year, are to be supplemented by ten similar vehicles which will have a top speed of only 62 m.p.h., but greater accelerative power, to enable them to haul trains of four or five standard coaches.

Spanish railways have a comprehensive programme in hand, but at the moment only eight vehicles are actually at work. Of these, the three Beardmore-engined 200 b.h.p. cars of the Pamplona-San Sebastian Railway have an aggregate mileage of about 400,000 to their credit, and an all-in cost including interest and depreciation of approximately 11d. per train-mile.

920 B.H.P EXPRESS OIL-ELECTRIC LOCOMOTIVE P.L.M. ALGERIAN SYSTEM

Other European railways which have adopted oil engine traction during the present year are the Lithuanian State Railways, with six 130 b.h.p. railcars; the Norwegian State Railways, with two 270 b.h.p. Mercédès-Benz cars; and the Esthonian State Railways, which is just putting into traffic three double-bogie cars. The decision of the Esthonian and Lithuanian authorities was doubtless influenced to some extent by the success of the small railcars on the Finnish State Railways, three of which have covered an aggregate of 550,000 miles since 1928, and five later cars an aggregate of 200,000 miles in eighteen months. Another four vehicles are to be set to work next summer.



600 B.H.P. BURLINGTON ZEPHYR

South America.

Apart from the United States, where the loans of the P.W.A. have worked wonders in the adoption of high-speed oil-engined trains, much of the present interest in extra-European countries centres in Argentina, where a number of British-owned railways

are actively engaged in giving a full-dress trial to railcars and locomotives. The experiments of the Buenos Ayres Great Southern Railway with mobile power-houses are well known, and so far as the three 1700 b.h.p. vehicles of this type sent out in February, 1933, are concerned, it may be recorded that they have covered respectively about 55,000, 55,000, and 45,000 miles in heavy suburban service out of Plaza Constitucion terminus. The main line locomotive of similar design and power has over 40,000 miles to its credit.

Some time ago, the Buenos Ayres Pacific Railway borrowed one of the original 1200 b.h.p. mobile power-houses of the B.A.G.S. Railway, built in 1929, to conduct tests on its own line. The two vehicles sent out normally work five-coach suburban trains on the lines of the owning company, and experience in their operation was used to advantage in the design of the 1700 b.h.p. units. Piston, crank shaft, valve, and bearing troubles caused a good deal of heart-burning in the early days, but the vehicles are now well-behaved. The original cast aluminium pistons were replaced by a heat-treated drop-stamped aluminium alloy, and the wearing properties of this new material have proved to be remarkable.

The Buenos Ayres Western Railway has just put into service one 450 b.h.p. oil-electric train and one 140 b.h.p. railcar, both of which were built on Tyneside. A further vehicle, of the same power as the last-named, is now being built in the Midlands, and will shortly be shipped to the River Plate. Further north, in Brazil, the triple-unit oil-electric train on the San Paulo Railway has been modified, and now carries first-class passengers only, the centre vehicle being fitted up as a *de luxe* car with a smoking room, buffet, and lounge.

The East.

Profiting, maybe, by the experience gained with oil engines under tropical conditions in Siam, both the Indian and Ceylon State Railways are taking up the new form of traction on main lines, the former with two Armstrong-Whitworth 1300 b.h.p. locomotives for the Karachi-Lahore mail service, and the latter with two 800 b.h.p. units for the Colombo-Talaimannar mail trains. The Ceylon locomotives have not been purchased, but are to undergo six months' trials on the basis of the railway supplying the drivers and paying the builders 75 per cent. of the cost of steam traction for the same mileage, the builders undertaking to maintain the machines. But such was the acrimonious debate and opposition raised in the Ceylon Parliament to these trials that no blame will attach to the Minister of Communications if he refuses to have anything more to do with oil engines.

Armstrong-Whitworth have also shipped railcars to the Kalka-Simla, G.I.P., and Madras and Southern Mahratta railways within the last eight months, but in the last two cases the car bodies are now being built in India. The order for these units was encouraged by the satisfactory performance of the 95 b.h.p. oil-electric railcars on the Gaekwar's Baroda State Railway. Nearer home, the Egyptian State Railways have just ordered ten railcars from Ganz, and the Syrian Railways six from France. In Africa an attempt is to be made to reduce the enormous operating expenditure of the Tunisian Railways by the introduction of twenty oil-engined railcars, and the newly-opened Congo-Ocean Railway is working a good deal of light passenger traffic by railcars having 135 b.h.p. Berliet oil engines.

North America.

After the introduction of the system *Rooseveltii*, the American railways, following a certain excellent precedent, looked round and found it good; hence the spate of oil-engined locomotives and trains which have been ordered since the beginning of the present year. The favour shown to streamlined 100 m.p.h. trains may be traced partly to the phenomenal performances of the "Burlington Zephyr," which, although not yet in regular service, has shown itself to possess a speed capacity by no means second to that of the "Flying Hamburger," and the owning company, the Chicago, Burlington and Quincey Railroad, has passed an order for two further trains of practically identical design. The Union Pacific Railroad, which led the way in American super-speed traction with the 600 b.h.p. distillate-engined train placed in traffic at the beginning of this year, has on order another train of six cars, which will include sleeping and dining coaches, and will be powered by a 900 b.h.p. oil engine of Winton manufacture. The New York, New Haven and Hartford Railroad is acquiring a 600 b.h.p. articulated train from the Goodyear-Zeppelin Corporation; the Gulf, Mobile and Northern has ordered two 600 b.h.p. trains from the American Car and Foundry Company; and the Boston and Maine one 660 b.h.p. set from the Budd Manufacturing Company, the builder of the "Burlington Zephyr." All of these are due for delivery next year, so that the end of 1935 should see at least nine 100 m.p.h. trains in the U.S.A.

In addition, the Baltimore and Ohio has drawn up designs for an express oil-engined locomotive of 1800 b.h.p. to run comparative tests with an equivalent steam locomotive with a heavy train of streamlined passenger cars, the cost of all this stock being financed by P.W.A. loans. It will be interesting to see if the Busch-Sulzer engine is incorporated in the B. and O. locomotive, for a single eight-cylinder unit developing 1600 b.h.p. has already been built, and sixteen cylinder designs developing 3500 b.h.p. are complete. Orders for about twenty switching locomotives have also been placed during the present year, in powers of 300 to 800 b.h.p., with Ingersoll-Rand, Westinghouse, Alco, and Winton engines, and a number have now been delivered. Apart from the Burmeister and Wain engine, of which there are about twenty-seven examples at work in Europe, the Winton is the only two-cycle engine which has made any headway in railway applications.

Canadian practice is limited to the twenty-eight railcars and four locomotives, all with electric transmission, the last of which was delivered as long ago as 1932. The 2660 b.h.p. articulated locomotive built by Beardmore in 1928, however, has been divided into two 1330 b.h.p. units, the first of which has been running in its new guise since August, 1933, and has covered about 35,000 miles.

Great Britain.

Experiences in Britain have been mixed. Even in shunting work teething troubles have occurred in several units. This is unfortunate, because in the present state of the art it should be, and is, possible to build a locomotive of this type and set it to work with no more trouble than is given by a steam engine. The new Great Western express cars, too, have not given all the satisfaction which was anticipated, but are now back in service. The original A.E.C. car is still operating an intensive traffic in the Thames Valley. Further north, the Armstrong-Whitworth cars of the "Tyneside Venturer" class are working fast supplementary services in Yorkshire, with maximum speeds up to 68 m.p.h. or so.

Oil engine shunting is being tackled by the L.M.S.R. in a manner calculated to make it go, and this company has shown its confidence in the future of such units by the consideration of designs for locomotives up to 300–350 b.h.p. But there is a tremendous scope for passenger traffic operation by railcars, not only in stopping services with quick schedules, such as is maintained on the L.M.S.R. by the Leyland cars, but also in the realm of high sustained speed, and the ordering of a super-speed streamlined oil-electric articulated train by one of the Big Four in this country would not come as an unheralded shock.

Conclusion.

Consideration of oil engine railway traction and its development during the last two years shows an overwhelming preponderance of railcars and set trains, almost to the exclusion of the locomotive, apart from shunting duties. It may be that the 700-odd oil-engined railcars and trains now at work throughout the world are but harbingers of a new era in railway working, in which the comparatively infrequent and heavy passenger train will give place to a rapid and frequent service of light self-contained units, which will provide maximum facilities to the public with a minimum of attention and repair.

University Degrees in Engineering.

No. V.

(*Continued from page 505, November 23rd.*)

Oxford University.—The degrees awarded to engineers by the University of Oxford are Bachelor of Arts—B.A.—Master of Arts—M.A.—Bachelor of Science—B.Sc.—Doctor of Philosophy—D. Phil.—and Doctor of Science—D.Sc. The degree of Doctor of Letters—D.Litt.—is also open to engineering graduates of the University.

At most other British universities the Bachelor of Arts degree is associated with the study of classics as the main subject rather than with that of science. In this respect the title has acquired a restricted significance. This restriction, in view of the institution of specific first degrees for students of law, medicine, theology, science, engineering and so forth, serves a useful purpose but it is not justified either etymologically or historically. Engineering, at least, is certainly as much an art as a science and it is therefore as reasonable to bestow the title Bachelor of Arts on an engineer as it is to call him a Bachelor of Science. At Oxford, following the old tradition, the B.A. degree is the first degree taken by students in all the faculties. When necessary the title may be extended to indicate the faculty in which the degree was taken. For example it may be given as B.A. in Jurisprudence, B.A. in Medicine, B.A. in Modern Languages or B.A. in Engineering Science.

The Master of Arts degree is nominally a second or more advanced degree. It is not, however, obtained, as at certain other English universities which give both the B.A. and the M.A. degrees, by additional study and examination. No academic test of any kind is imposed upon a candidate for the M.A. degree. It is open to any holder of the University's B.A. degree who, having had his name on the books of one of the Societies—that is one of the various Colleges or Halls—for a period of twenty terms, pays a prescribed fee. The process of keeping one's name on the books of a Society consists simply in refraining from withdrawing the £10 to £30 deposited as "caution money" on commencing residence and reclaimable, if not forfeited, at the end of the B.A. course.

It will be gathered that at Oxford the B.A. degree in engineering science is the equivalent, at least in order of precedence, of the B.Sc. or B.Eng. degree awarded to engineers by other universities. The M.A. degree is not, however, correspondingly equivalent to the M.Sc. or M.Eng. degree which other universities usually award for post-graduate research work. The research degree at Oxford corresponding to the M.Sc. or M.Eng. degree of other universities is the B.Sc. This system of degree titles may be confusing when comparison has to be made between Oxford and other universities but within the University itself it is part of a consistent scheme. The first degree in all the faculties is, as has been said, the B.A. The purely nominal M.A. degree being omitted, the next higher degree indicates by its title the specialised field in which the holder has continued his studies. For example a Bachelor of Arts who has taken his degree in jurisprudence may by additional study and examination proceed to the degree of Bachelor of Civil Law, a B.A. in Medicine may proceed to the degree of Bachelor of Medicine—B.M.—and a B.A. in Theology may proceed to the degree of Bachelor of Divinity—B.D. It is therefore consistent that a B.A. in engineering science, or in any other of the branches into which the University divides Natural Science, should proceed to the degree of Bachelor of Science.

Having passed the University's Matriculation examination—"Responsions"—and—if one is in force or required—an additional entrance examination imposed by the Society which he has selected, the student, if accepted, becomes a member of the University and can proceed with his studies for his degree. These studies lead to two examinations, known as the first and the second public examinations, and normally extend over nine terms or three years. The terms begin about the middle of October, the third week in January and the end of April and each covers about eight weeks. Residence within the walls of one of the Colleges or Halls or in licensed lodgings is an essential part of term-keeping.

The first public examination so far as engineering students are concerned covers mathematics, mechanics and physics, and chemistry. Candidates are required to satisfy the examiners in two of these subjects. They may present themselves for this examination at any time after they have passed Responsions and are permitted to offer their subjects at separate examinations. For the second public examination papers are set in applied mechanics, the theory of structures, heat and heat engines, applied electricity, applied chemistry and surveying. There are nine papers in all in these subjects and they must be taken by all candidates. In addition one or two general papers are set containing questions of a more advanced character in any of the subjects just named and, at the examiners' discretion, questions relating to any special course of lectures which may have been delivered at the Engineering Laboratory during the academical year of the examination. It is not obligatory upon candidates to take these additional papers but excellence in them may be regarded as compensating for comparative deficiency in some other part of the examination. There is no practical examination in any of the subjects but in substitution for it the examiners assess the practical work done by the candidate during his course of study. Candidates are normally not permitted to take the second public examination earlier than in their eighth term after matriculation nor later than in their twelfth term. The names of successful candidates are published in four classes of merit, corresponding to first, second, third and fourth class honours.

It will be noted that no distinction is made between civil, mechanical and electrical engineers and that the course provided is, throughout, an "honours" course. No provision is made for an "ordinary" degree in engineering science although doubtlessly it would be justifiable to consider a fourth-class honours degree as equivalent to the "ordinary" degree of other universities.

The B.Sc. degree is open to Bachelors of Arts of the University who are qualified to undertake research in mathematics or natural science. It is also open to graduates of other approved universities and in exceptional cases to non-graduates. Candidates for the degree are required to have their names on the books of one of the Societies. The proposed subject

of research having been approved by the Board of the appropriate faculty, the candidate is placed under the charge of a graduate member of the University whose duty it is to direct and supervise the candidate's work but not to give him systematic instruction. The research course has normally to be pursued at Oxford. At any time after the second term of his work and before the eighth term the candidate may submit a thesis embodying the results of his investigation and undergo an oral—and, if required, a written—examination on the subject of his thesis. The degree is awarded if the thesis and the examination exhibit a sufficient standard of merit. A candidate who fails in his application may be re-admitted and may represent himself after a further period of four months.

The B.Sc. degree is regarded by the University as evidence that the holder has "served an apprenticeship in research." The D.Phil. degree is awarded in recognition of advanced research work and is open to holders of the B.Sc. degree or to holders of the B.A. degree with first-class honours. It is also open to other holders of the B.A. degree who produce evidence of their fitness to pursue advanced studies and to graduates of other universities on similar terms. Candidates are required to keep their names on the books of a society continuously throughout the period of their advanced studies. On being admitted as an advanced student the candidate is placed under a graduate member of the University or other competent person who directs and superintends his work but does not give him systematic instruction. The candidate's studies or research must extend over at least six terms. At the end of that time or afterwards but not later than the twelfth term, unless special extension is granted, the candidate may submit a thesis on his work and undergo an oral or written examination on its subject. The candidate's work is required to result in an original contribution to knowledge and to be set forth in such a manner as to be fit for publication. The examiners have power to recommend that the candidate's application be referred back to him in which event he may represent himself for examination six to twelve months later. If the thesis and examination test do not reach a sufficiently high standard but reveal satisfactory merit the candidate may in place of the D.Phil. be awarded the B.Sc. degree.

The degrees of Doctor of Letters and Doctor of Science are awarded on the submission of published papers or books containing original contributions to the advancement of learning or science. One year at least must elapse between publication and submission of the paper or book. The degrees are open to Oxford Masters of Arts thirty terms after their matriculation, Masters of Arts of Cambridge or Dublin who have been incorporated in the University of Oxford after a like period, and to Doctors of Philosophy or Bachelors of Science who have had their names on the books of a Society for twenty terms from their matriculation.

Cambridge University.—The degrees open to engineers at the University of Cambridge are Bachelor of Arts—B.A.—Master of Arts—M.A.—Master of Science—M.Sc.—Doctor of Philosophy—Ph. D.—and Doctor of Science—Sc.D. The degrees of Master and Doctor of Letters—M.Litt. and Litt.D.—are also open to engineering graduates possessing the necessary qualifications and fulfilling the necessary conditions.

The B.A. degree is the first degree taken by students in most of the faculties. The M.A. degree, as at Oxford, is a purely nominal one and is obtainable by Bachelors of Arts on payment of prescribed fees six years after the end of their first term of residence at the University. The higher degrees obtainable by additional study and examination bear titles—such as B.D., LL.B. and so forth—indicative of the specialised field of study cultivated by their holders. There is, however, no degree of B.Sc. Graduates in engineering, or other branch of science, may proceed instead to the M.Sc. They may alternatively proceed by additional study to the M.Litt. degree.

Before he begins residence a student must have passed the "previous examination" and, if required, a special entrance examination imposed individually by the College or Society which he has selected. Engineering students may elect to study for honours or to take the "ordinary" B.A. degree. In the first case the course of study followed leads to the Mechanical Science Tripos* success in which will result in the student obtaining the B.A. degree in mechanical science with first, second or third-class honours. If a candidate fails in the tripos he may be awarded the "ordinary" B.A. degree or be allowed to proceed to that degree after a certain amount of farther work. Alternatively a candidate may aim from the outset only at the ordinary B.A. degree by following a modified course of engineering studies.

Normally the course for the mechanical science tripos extends over three years. A candidate is required to pass a qualifying examination in mathematics and mechanics as a first step. This examination may be taken before he begins residence or at any opportunity before the end of his fourth term of residence. Two preliminary examinations covering the subjects of the tripos are taken during the first and second years. These examinations are designed to test the candidate's progress. Failure to take or pass them does not debar the candidate from proceeding to the tripos examination. If however a candidate after passing these preliminary examinations satisfactorily fails in the tripos examination—for which he may present himself only once—his success in the first and second preliminary examinations will be counted as equivalent to success in the first and second of the three examinations which, as detailed below, have to be taken by candidates for the "ordinary" B.A. degree. The tripos examination is normally taken at the end of the third year. It consists of sixteen papers divided into two sections. The whole of the examination must be passed as a single examination; it is not divided, as are the other triposes, into two, or three, parts which may be taken successively. The subjects included in the first section of the mechanical science tripos are applied mechanics, mechanics of machines and hydraulics, theory of structures, heat and heat engines, applied electricity, chemical and physical properties of materials, drawing and an essay. All candidates are required to take the papers of this section. They may obtain second or third-class honours by their performance in this section but if they desire first-class honours they must take additional papers from the second section. The subjects of the papers in this section are applied mechanics, mechanics of machines, theory of structures (civil), theory of structures (mechanical), heat and heat engines, electric power, electric signalling and aeronautics. Where these subjects are identical with those of the first section the questions set in them are of greater difficulty or wider range. To obtain first-class honours a candidate must acquit himself with special merit in two papers selected from the second section or with special merit in one paper and with merit in two others. All candidates in addition to passing the written examination are required to satisfy the examiners that they can perform simple laboratory tests and experiments and workshop operations, can make and interpret drawings, can adjust and use surveying instruments and can plot the results of a simple survey. A candidate who fails to pass the mechanical science tripos may with or without additional work qualify for the "ordinary" B.A. degree.

In addition to the course for the mechanical science tripos the University provides a course leading to a certificate of proficiency in engineering studies. By obtaining this certificate a candidate qualifies himself for the "ordinary" B.A. degree. The examinations under this heading are three in number and are normally taken in succession. The first examination covers mathematics, applied mechanics, engineering physics and the properties and testing of materials. The second examination comprises papers in applied mechanics and engineering drawing and two papers selected from the following list:—Theory of structures, heat engines, applied electricity, hydraulics and surveying, aeronautics, and mechanics of machines. The third examination covers two farther subjects selected from the above list together with papers in engineering drawing, administration, workshop organisation and production, and industrial processes, power generation and distribution. In the second and third examinations candidates are required to satisfy the examiners in workshop practice covering woodworking, metal-working and forging.

The research degrees at the University are the M.Sc., M.Litt. and Ph.D. For the M.Sc. and M.Litt. degrees candidates are required normally to spend at the University a period of at least two years on an approved course of research conducted under an appointed supervisor. For the Ph.D. degree the period of research is at least three years. Not later than twelve terms after his appointment as a research student the candidate is required to submit a dissertation on his work and subsequently to undergo an examination, oral or otherwise, on it and on the general field of knowledge within which it falls. If the dissertation is not of sufficient merit the candidate may be allowed to revise it and re-submit it. In connection with the Ph.D. degree it is provided that if the candidate does not attain the standard required for that degree he may be recommended for the M.Sc. or M.Litt. degree. The degrees are open to graduates of other universities but in all cases residence at Cambridge during some or the whole of the period of the research is required.

The standard required for the Ph.D. degree is definitely higher than that required for the M.Sc. or M.Litt. degree. It is not possible from the regulations to discover the official difference between the two Master's degrees. It would appear to be within the power of the Board of Research Studies and of the Degree Committee of the Faculty with which the proposed research appears to be most nearly connected to determine for which degree an applicant may be allowed to become a candidate. The term research is clearly meant to cover not merely experimental investigation of a physical, chemical or similar nature but also documentary study. While normally an engineering graduate would chose as his subject some work of an experimental scientific nature and would thereby presumably place himself in candidature for the M.Sc. degree he might as an alternative select to investigate some aspect of, say, the growth of trades unionism in this or some other country or some particular field of technological history. Presumably in the latter event he would become a candidate for the M.Litt. degree.

That the distinction between the M.Sc. and the M.Litt. degrees is not very precise may be inferred from the regulations governing the higher degrees of Sc.D. and Litt.D. The ordinances of the University state that "a student proceeding to the degree of Doctor of Science or of Letters shall be required to give proof of distinction by some original contribution to the advancement of Science or of Learning." The word "respectively" is, presumably, omitted purposely in order to avoid the necessity for defining the difference between science and learning.

Candidates for the Sc.D. or Litt.D. degree are required to be graduates of the University of at least eight years' standing. The contributions to the advancement of science or learning submitted in support of their applications must have been published.

The ordinances of the University permit titles of degrees to be conferred *honoris causa* on members of the Royal Family, on British subjects who are of conspicuous merit or have done good service to the State or to the University and on foreigners of distinction. An honorary degree is in the nature of a compliment and confers no rights other than that of borrowing books from the University library.

(To be continued.)

* The name "tripos" is peculiar to the examinations for degrees with honours at Cambridge. There are triposes in fourteen branches of learning. The name is derived from the fact that successful candidates are graded in three classes.

The Machine Tool and Engineering Exhibition at Olympia.

No. IV.

(Concluded from page 511, November 23rd.)

Alexander Duckham and Co. Ltd.

On the stand of Alexander Duckham and Co. Ltd. of 16, Cannon-street E.C.4 there was included a representative display of "Keenol" lubricating oils and greases and of articles and parts which had been run in service with such oils and greases as the lubricants and, for comparison, similar parts which had been run with ordinary lubricants. Messrs. Duckham have now taken over the manufacture of "Keenol" lubricants. These oils and greases are characterised by the fact that varying percentages of zinc oxide are incorporated in them. In use steel or iron surfaces running in contact under pressure become, in the presence of "Keenol" lubricant, coated with a film of metallic zinc. The thickness of this film was found by the late Dr. Rosenhain to be of the order of 0·0004 mm. or less than the average wave length of white light. This thickness is too small to affect the tolerance or working clearance of the coated parts. Once formed the film does not increase in thickness. It is believed that the plating action results from the establishment of an electric stress in the neighbourhood of the areas of the metal surfaces which are in contact and that the deposition of the metallic zinc takes place continuously and is accompanied by a re-oxidation at the same rate. The oxidation of the zinc film and its continuous renewal protect the underlying steel or iron surfaces from oxidation. The lubricant therefore inhibits corrosion. It also reduces or eliminates wear, the reason advanced being that wear or abrasion is fundamentally, in large part or wholly, a form of corrosion. The production of rust in the entire absence of moisture can, as is well known, occur between steel or iron parts working in contact under pressure. "Keenol" lubricants have been found to be as effective in these circumstances as when moisture is present. The zinc film although it is continuously being removed and redeposited when the parts are in service is remarkably permanent after the parts are withdrawn from operation. We have in our possession coated parts which were submitted to us for inspection 5½ years ago. They have been exposed unprotected to the atmosphere throughout the whole of that period and have been repeatedly and freely handled. The zinc coating is to-day almost as bright as when we received the parts; only here and there are spots of rust beginning

to show through it. A descriptive article and a leading article on the scientific aspects of this extremely interesting lubricant will be found in our issue of September 27th 1929.

The mechanism by which the zinc film is formed is, we gather, not more fully understood to-day than it was in 1929. On the production side, however, advance has been made in preventing the settlement of the zinc oxide when the oil or grease is left undisturbed. This improvement has been effected by exercising care in the selection of the zinc oxide employed and by alterations in the production process, both these steps being designed to ensure that the zinc oxide shall approach as nearly as possible to being in a state of true colloidal suspension. On the employment side an interesting and important development has consisted of the use of "Keenol" lubricants for drawing and pressing work. Favourable results in this connection have been reported to us in connection with the drawing of brass and stainless steel. It is believed that the beneficial action of the lubricant in these circumstances depends upon the mechanical action of the oxide and that the sponge-like particles hold the lubricant firmly on the surface of the metal and largely prevent the lubricant being extruded under the great pressure to which the metal is subjected.

On Messrs. Duckham's stand there were shown a number of gear wheels and roller bearing races which had run in heavy omnibus service some with ordinary, and some with "Keenol," lubricants. Those parts which had run in the presence of the second-named lubricant exhibited the characteristic zinc-plated surfaces where the parts had been in contact under high pressure. Among the exhibits was the sliding pinion of a gear change box which had been in service for 186,000 miles with "Keenol" as the lubricant. Another exhibit consisted of the steering worm and wheel of an omnibus after running 100,000 miles with the same lubricant but perhaps the most interesting item shown was a gear wheel which had been scrapped after 135,000 miles with ordinary lubricant but which had been put back into service with "Keenol" and had run for a farther 70,000 miles. Other exhibits illustrated the use of the lubricant for the prevention of corrosion at the fulcrum pins in the brake drums of motor vehicles, at the ball races of a grinding mill subjected to very heavy shock loads and in the starting motors of certain heavy types of road vehicles which had given considerable trouble from corrosion induced by moisture.

Desoutter Brothers, Ltd.

The stand of Desoutter Brothers, Ltd., The Hyde, Hendon, London, N.W.9, was devoted to high-

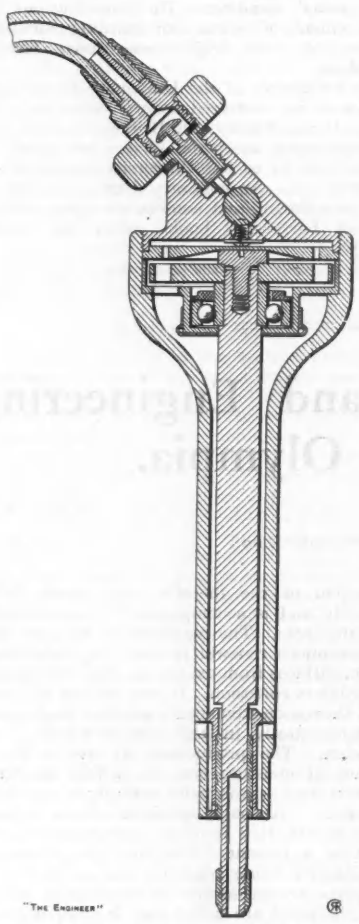


FIG. 49—AIR TURBINE-DRIVEN PORTABLE TOOL—DESOUTTER

power electric drills and small pneumatic tools. One of the latter, driven by a new high-speed air turbine, is illustrated in Fig. 49. It is intended for die sinking and tool making work, and as spindle speeds as high as 70,000 r.p.m. can be attained, very small grinding wheels can be used to work out small radii. Incidentally, the tool weighs only 12¼ oz., so that it is very easily handled. The turbine is a single disc impulse wheel with shrouded vanes that produce an almost complete reversal of the air jets and thus give a good efficiency. The end thrust on the spindle is taken by a ball bearing, while the chuck end of the spindle runs in a journal bearing made of a porous alloy. This bearing is lubricated with oil which percolates through the alloy in minute quantities, and maintains the lubrication without clogging, which would quickly reduce the speed. The ball bearing is lubricated with grease. The exhaust air from the turbine is conveyed down the duralumin casing and keeps the running parts cool. The control of the air supply is effected by a push button with a spring lock in the "on" and "off" positions. To get a speed of 70,000 r.p.m. an air pressure of 100 lb. per square inch is required. The air consumption is then 5 cubic feet per minute. A pressure of 50 lb. gives a speed of 45,000 revolutions.

Sciaky Electric Welding Machines, Ltd.

Electric spot welding machines fitted with a patented automatic cut-out were exhibited by Sciaky Electric Welding Machines, Ltd., of Blossoms Inn, 23, Lawrence-lane, Cheapside, E.C.2. The machine shown in Fig. 51 is suitable for single spot step-by-step welding, or continuous spot welding. By adjusting the lower arm the distance between the electrodes can be varied between 14in. to 30in., the length of the electrode travel being 0 to 2in. The transformer is rated at 80–120 kVA. Steel sheets or scaled steel sections of equal thickness can be welded to give a total thickness of $\frac{9}{16}$in. Workpieces of unequal thicknesses can also be welded, provided the ratio of the thicknesses does not exceed 1 to 10, and the maximum total thickness does not exceed $1\frac{3}{16}$in. The machine is operated by compressed air and when the foot pedal control switch has been depressed, it is entirely automatic in action. The special control system is claimed to ensure that all the welds are sound and uniform. A contactor switch with its coil controlled by a relay which compensates for variations in the supply voltage, serves to switch the current on and off, and ensures that each weld receives the proper amount of electrical energy to heat the metal to the correct welding temperature.

The top electrode is moved by a pneumatic motor which by means of the special control apparatus gives the following cycle of operations for each spot :—The top electrode is moved into contact with the work ; heavy pressure is applied to bring the work pieces into close contact ; the welding current is switched on by a contactor switch ; pressure on the electrodes is reduced during the heating period ; the welding current is switched off by the contactor, and heavy pressure is applied to complete the weld. During the heating period the decrease in pressure occurs in a manner that ensures that the softening of the metal still allows a close contact between the work pieces, and the final heavy pressure on the hot metal gives a true weld of high quality. Both the initial pressure and that during heating are easily controlled. The pedal is arranged so that if required it is possible to bring the electrodes into contact with the work and to apply and release the initial pressure without carrying out the welding operation, thus enabling the correct mechanical conditions to be established before beginning to weld. Once the pedal has been fully depressed, the cycle of operations is completed automatically, even if the pedal is released before the weld is finished. As long as the pedal is kept down, the machine continues to operate and makes a consecutive series of spots. If isolated spots are required, the pedal is released after each weld.

The rate of automatic rise and fall of the electrode can be regulated for consecutive welding from 25 to 150 spots per minute. A special control device ensures that the welding current is not switched on until the correct pressure is being applied to the work. The top and bottom electrodes are adjustable in the arms and movable in all directions horizontally. The electrode pressure is independent of the stroke, of the distance between the electrodes and of the variable thickness of the work pieces to be welded and within the limits of 60 lb. to 100 lb. per square inch of the pressure in the compressed air system.

With the machine shown in Fig. 50 welding pincers of various kinds are employed ; and the makers also design special tools for specific jobs, for which the standard types of pincers are unsuitable. All electrodes have movable tips. The machine is suitable for making isolated spots or a consecutive series of spots with mild steel sheets or sections, up to a total thickness of $\frac{5}{16}$in. composed of work pieces of equal thickness. It may also be used for welding sheets of unequal thickness up to a total thickness of ½in., provided, as in the case of the other machine, that the ratio of thickness does not exceed 1 to 10. The machine is particularly suitable for spot welding motor car bodies and frames, and for work of a similar nature that can be carried out most advantageously by taking the tool to the job. The welding set consists of a transformer with its associated control

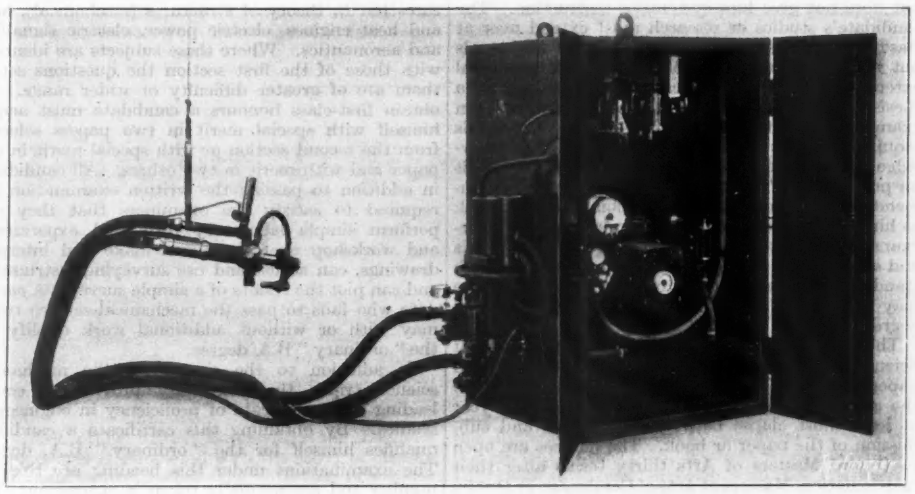


FIG. 50—SPOT WELDER—SCIAKY

apparatus mounted in a steel case. Heavy water-cooled flexible cables are taken from the transformer secondary terminals to the welding pincer, which is suitably suspended and balanced to enable the operator to perform the work without undue fatigue.

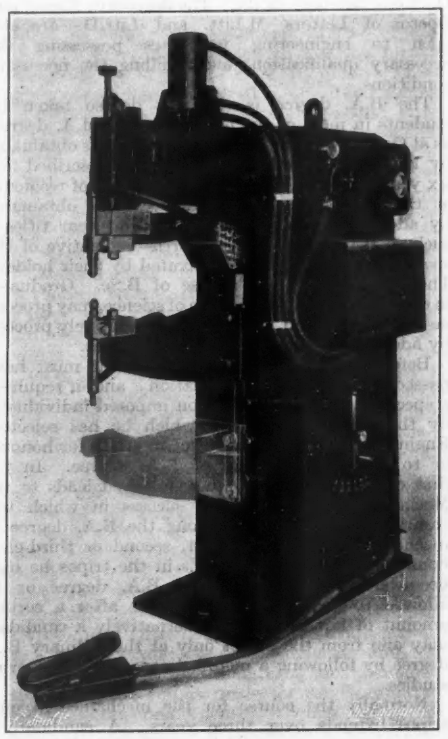


FIG. 51—ELECTRIC SPOT WELDER—SCIAKY

The movable electrode of the pincer is operated by a piston working in a cylinder under a hydraulic pressure up to 1500 lb. per square inch, conveyed to the pincer through a flexible tube from a hydraulic pneumatic relay fixed to the transformer case. As the necessary pressure is provided by compressed air

of about 100 lb. per square inch, acting under control in the hydraulic pneumatic relay, no separate high-pressure water supply is needed. The electrode pressure is easily regulated, and is independent of the length of stroke, distance between electrodes and variation in the thickness of the work. A small pneumatic push-button on the welding pincer serves for putting the machine into operation. What has been said with regard to the special control system applied to the machine Fig. 51, also applies to this welding set with pincers, which is provided with a safety device to prevent the welding current being switched on if the water circulation is defective.

Lumsden Machine Company, Ltd.

A number of grinding machines made by the Lumsden Machine Company, Ltd., of Gateshead, were exhibited on the stands of Alfred Herbert, Ltd. The segmental wheel, vertical spindle, reciprocating table surface grinder illustrated in Fig. 52 has been produced to meet the requirements of those who prefer a

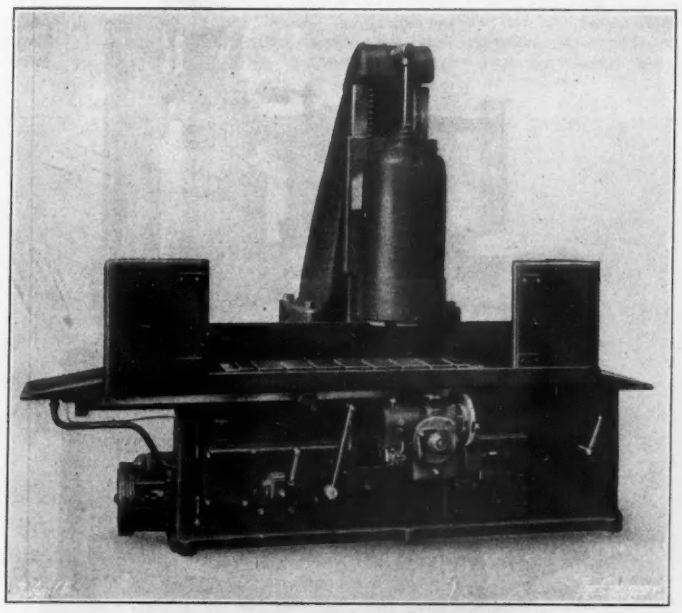


Fig. 52—Reciprocating Table Surface Grinder—Lumsden

built-in rather than a detachable motor. The spindle is mounted in a specially built motor head, which slides upon narrow adjustable guides on a massive column, and is over-balanced by a deadweight. One vee and one flat way carry the table on the bed, and the latter houses the whole of the hydraulic equipment. The length of stroke is adjusted by tappets. The feed mechanism is fitted at a convenient point on the front of the bed. There is an automatic adjustable down feed and a motor drive for quickly raising or lowering the head.

The other machine, illustrated in Fig. 53, is specially adapted for the grinding of tungsten-carbide

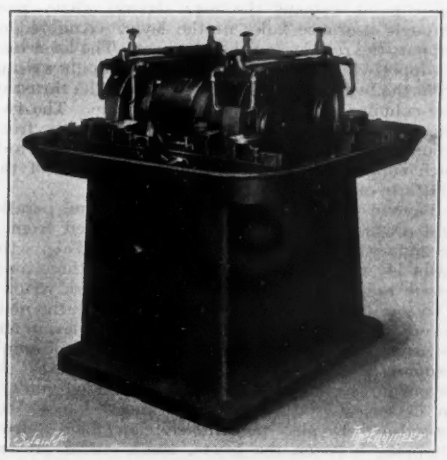


Fig. 53—Tool Grinder—Lumsden

tools. For this purpose it is essential to have four grinding wheels, one for the shanks or for high-speed steel, one for roughing, one for intermediate finishing, and one for burnishing. As all grinding must be done with the wheels running down double cup wheels are essential for dealing with left and right-hand tools. The requirements are met by a two-spindle machine with spindles running in opposite directions. The motor head of the machine is built in and the spindles are carried in suitable bearings to ensure especially smooth running. Eight rests are provided, all adjustable for wheel wear without interference with the screw setting for angle. A single pump supplies water to the wheels and the quantity is adjusted by a separate valve above each wheel.

Buck and Hickman, Ltd.

One of the most interesting machines on the stand taken by Buck and Hickman, Ltd., of Whitechapel-road, London, E.1, was the Pratt and Whitney 10in. hydraulic gear grinder, illustrated in Fig. 54. This machine makes use of a wheel, the two sides of which are ground to the shape of the basic rack of the involute. The operating principle is very simple and accurate. A reciprocating horizontal ram, somewhat similar to that of a horizontal shaper, carries the grinding wheel back and forth through the teeth, generating the adjacent sides of two teeth at once. The wheel is trued with straight sides and top, corresponding with the shape of a tooth in a master rack. The stack of gears being ground is rolled past the reciprocating wheel under the guidance of a master gear and rack, so that the wheel always engages the work tooth for tooth as the master rack engages the master gear. The wheel makes as many passes per tooth as are necessary for the finish desired. The work is indexed automatically when it has rolled to one side out of engagement with the grinding wheel. The machine stops automatically when all teeth are finished. Spindle speeds of 2215 and 2500 r.p.m. are available and the power is supplied by a 2 h.p. motor carried in a housing on the ram and driving the spindle through a belt. A 5 h.p. motor mounted under a cover on the side of the bed drives the oil pump for the hydraulic motions. The ram stroke is adjustable for length and position and has a maximum motion of 6¾in. It is produced hydraulically and any speed up to 60ft. per minute can be obtained. The table is also driven hydraulically and has two speed ranges, a slow one for grinding and a rapid one for indexing. Gear blanks to be ground are mounted on arbors carried between centres. For helical gears the work slide which is mounted on a swivel base is set to the helix angle of the gear to be ground. The work slide moves perpendicularly to the centre line of the work and the helical gear is generated by a combination of straight line and rotary movements.

A master gear is mounted on the end of the work spindle. This master is a duplicate of the gear to be ground in number of teeth and face diametral pitch, and is thus of the same pitch diameter as the work. It does not need to be a duplicate in pressure angle. Master gears and the racks used with them are made of hardened and ground steel, and one three-piece master rack is required for each diametral pitch to be ground. The master rack is mounted on an arm, which pivots horizontally to bring the rack in mesh with and just above the master gear. The pivot is adjustable vertically for master gears from 1in. P.D. to 10in. P.D. The motion of the work past the grinding wheel is accomplished by the rolling of the master gear along the master rack. Immediately above the master rack there is a slide on which are mounted two indexing racks. The indexing rack slide moves between adjustable stops, and is moved the distance between two rack teeth at each end of the table stroke. It is operated by a hydraulic piston motor, which is controlled automatically by a valve. The motion of this slide indexes the master gear and the work, as its motion rotates the master gear one tooth. Indexing takes place at either end of the table movement, while the master gear is out of mesh with the master rack and in mesh with either indexing rack, the work at the same time having rolled to one side out of contact with the wheel. Wheel dressing is carried out by three diamonds, one in each of three sliding bars operated by a single lever. The two bars for dressing the sides of the wheel are independently adjustable by a vernier to angles from 13 deg. to 30 deg. by minutes. The third bar is used for dressing the outside of the wheel and is not adjustable. There were numerous other machines on the Buck and Hickman stand, but unfortunately we have not sufficient space available to describe them. The Brown and Sharpe automatic screw machines and the Bullard vertical lathe attracted a good deal of attention.

Reavell and Co., Ltd.

The exhibit of Reavell and Co., Ltd., of Ranelagh Works, Ipswich, was confined to a series of standard air compressors, such as might be of service in engineering works and factories using machine tools. On one of the stands of A. C. Wickman, Ltd., we also noted a Reavell air compressor supplying air to pneumatically operated chucks. One of the largest stand exhibits was a vertical double-acting two-stage machine designed to run at 415 r.p.m., and to take

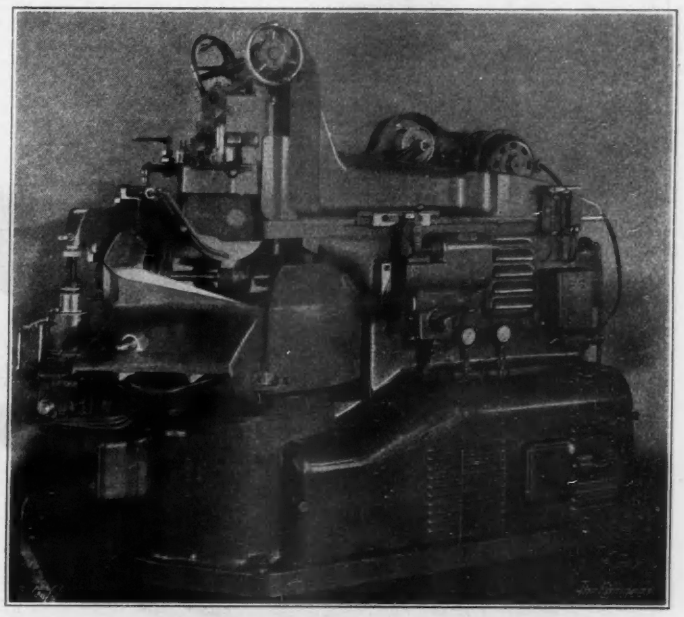


Fig. 54—10-Inch Hydraulic Helical Gear Grinder—Buck & Hickman

about 160 b.h.p., when delivering air at 100 lb. pressure, and 175 b.h.p. when working at 120 lb. delivery pressure. A single-acting vertical machine of like capacity designed for pressures up to 40 lb. per square inch, which is representative of a range of machines from 500 up to 5000 cubic feet, was also on view.

A group of single-acting air compressors which have been specially designed for factory services of 100 lb. per square inch, included eight machines covering outputs from 1 up to 360 cubic feet of free air delivered per minute. These machines are water-cooled in all the larger sizes. We also noted several examples of Reavell rolling drum and quadruplex pattern rotary machines, and a display of air-operated tools, such as concrete breakers.

The Rapid Magnetting Machine Company, Ltd.

Besides magnetic chucks, clutches, &c., and lifting magnets, the Rapid Magnetting Machine Company, Ltd., of Birmingham, exhibited the new "Rapid-Biaflux" drum type separator, for which very considerable advantages are claimed. Perhaps the most important improvement embodied in the new separator is that the "neutral zones" which have heretofore existed between the poles of the magnets, have been eliminated, so that there is no longer the possibility that a piece of iron which happened to be fed on to the drum above a neutral zone will fall off into the cleaned material.

There are two main types of separator—the drum and the pulley. In the first named material is fed on to a rotating drum by a chute. The drum encloses within it a magnet of half-moon shape, which exerts its pull over one half of the circumference and thus the iron falls off from the bottom of the drum as it passes out of the influence of the magnet. In the pulley type the whole pulley is a magnet over which a belt runs. Owing to the magnetic pull the iron adheres to the belt until the latter leaves the pulley, when it drops off. Unfortunately for the efficiency of the latter type of arrangement, the belt seriously affects the strength of the magnetic pull. Where, for instance, the uncovered pulley will exert a magnetic pull of 80 lb. per square inch, the introduction of a belt $\frac{3}{16}$in. thick will reduce the pull to 10 lb. per square inch. The company had in this connection a very important development to demonstrate. By the use of "the Rapid-Biaflux" belt system, it is claimed a magnetic pull at least 100 per cent. greater than that obtained through an ordinary conveyor belt is obtainable. We learn from the makers

that at present the new system has certain limitations, but it is believed that as the result of further experiments these limitations will be overcome.

JOHN HOLROYD AND CO., LTD.

One of the most interesting machines exhibited at Olympia was the worm grinding machine made by John Holroyd and Co., Ltd., of Milnrow, and illustrated in Fig. 55. The abrasive wheel is a ring of large diameter cemented to a metal plate with its axis at right angles to the axis of the work, the periphery being used for grinding. The shape of the inside of the wheel is such that no interference takes place with the adjacent thread. Right-hand threads are ground by using the right-hand side of the abrasive wheel, and left-hand threads by using the left-hand side of the wheel. Two diamond truing devices for dressing the wheel are arranged on the front face of a fixed upright, which forms a bridge under which the wheel head is adjusted, so that the diamonds are always in a fixed position in relation to the work. One diamond is used for truing the front face of the wheel and the other for producing the necessary shape on the outside periphery of the wheel to give the desired thread profile. Almost any type of profile can be produced by the use of shaped formers. These formers are fastened on to the truing device and the diamond follows the path on the former plate and reproduces the shape on the wheel. As the wheel wears, successive dressings are carried out by advancing it to the diamonds. The wheel head is provided with vertical adjustment and can also be slightly swivelled. These adjustments are required for setting the axis of the wheel in relation to the longitudinal axis of the worm so that no interference takes place between the adjacent thread and the inner surface of the wheel.

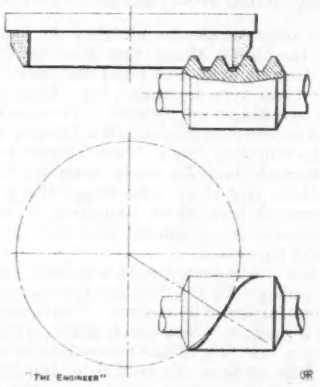


FIG. 56—PRINCIPLE OF WORM GRINDER

The diagrammatic line engraving—Fig. 56—illustrates the principle on which the machine acts. The wheel grinds on its outer diameter and the axis of the worm is set below that of the wheel a distance sufficient to produce the desired lead. One side of the worm is ground at a time. The worm is traversed in the usual manner in a direction parallel to its axis and also revolves on its axis. These two motions, of course, are suitably adjusted to suit the desired lead. In the case of worms with more than one "start" indexing takes place on the return stroke, during which the table backs out.

Several advantages are claimed for this method of grinding worms; any desired thread shape can be produced and accurately reproduced at any subsequent time; the tooth finish is such that no subsequent polishing is necessary; heavy cuts may be taken; and an allowance of 15 to 20 thousandths of an inch may be removed and the worm thread finished by two or at the most three passes of the wheel.

The general construction of the machine can be followed from the tone engraving. It is particularly intended for the production of automobile worms and will admit diameters up to 12in. and lengths between centres of 3ft. 6in. For the accommodation of long shank worms the head is provided with a hollow spindle, 3¼in. internal diameter. The machine is fully automatic, is driven electrically, and controlled by push buttons arranged upon a plate beside the operator's position.

EDWARD G. HERBERT, LTD.

Most of the tools and machines exhibited by Edward G. Herbert, Ltd., of Levenshulme, Manchester, we have described before in our pages, but the Olsen testing machine, illustrated in Fig. 57, and built in this country under licence by the firm, is new. This machine is one of a range all operating on the same principle, but designed to carry out special tests, and on account of its possibilities is known as the "Universal" machine. It can be used for tension, compression, or transverse tests, and when fitted with special tools for shearing and bending tests. In the particular machine exhibited the strain is applied by four screws fixed to the travelling crosshead and encircled by rotating nuts. The driving nuts turn on the threaded lower ends of the straining screws, which pass through holes in the weighing platform and through openings in the levers and the bed plate, which forms the top of the base. Each nut has a large gear wheel, which engages with the central pinion, and all the nuts are turned by the pinion. Feathers fitted into longitudinal slots cut through the threads prevent the screws from turning. The nuts are held between the bearing frame at the bottom and thrust collars which bear against the bed plate at the top. Between the bed plate and the top of each nut is a thrust bearing, against which the nut turns when tension is being applied to the screws. It will be seen that by this arrangement the straining system is maintained independent of the weighing system, and that the screws are not required to take any bending or twisting stresses. Moreover, the space between the crossheads is clear of rotating parts, and since the screws are arranged close beside the uprights, access to the test piece is easy. The direction of travel of the crosshead can be controlled upward or downward by the movement of a single lever.

A lever system supports the platform and transmits the load to the scale beam where it is weighed. The levers are provided with knife edges fitted accurately in machined slots and ground exactly to gauge, so that they will function as a single unit. All levers are designed and constructed so that the pressure on the knife edges falls within the requirements of the various testing bureaux, such as Lloyd's Bureau of Shipping and the American Bureau of Shipping. A dial vernier screw beam is fitted to the machine that was exhibited at Olympia. The screw that moves the poise is operated by a conveniently placed hand wheel. As is usual in this type of arrangement, a small lever on the poise when pressed allows it to be moved independently of the screw. If automatic adjustment of the poise is arranged for autographic attachments can be used.

The weighing platform rests wholly on the short arms of the main levers, and any pressure on it is transmitted directly to the levers. Four bars extend from the bed-plate through the corners of the weighing platform and have nuts with rubber washers, which serve to take up the shock when a large specimen gives way. The nuts are not screwed down tightly and the washers do not press against the platform, except when it recoils. In the case of high-capacity machines the recoil is absorbed by hydraulic cylinders in addition to the rubber washers. On smaller machines these hydraulic cylinders are not required. The middle lever is longer than the others and runs back to a point beyond the rear screws, which pass through clearance holes in the lever. Knife edges support the rear legs of the platform. The lever also is supported by the two knife edges upon pillars rising from the bed-plate. This lever receives the thrust of the columns at the rear of the machine. The two short levers, which receive the thrust from the front columns, are equal in length and curved outward, each supporting two of the four front legs of the platform on knife edges.

Beyond the platform, the two levers run parallel and are supported in a stirrup suspended from a secondary multiplying lever, which is placed above the main levers and parallel to them. The three main levers are so proportioned that they work as one. The secondary lever is of the same class as the main levers. A strong framework encloses the levers and is secured to the base by a diagonal brace of ample proportions. This framework which encases the levers also carries the supports for the scale beam and in many cases serves as a working table for the operator. It also prevents foreign matter from dropping between the levers, which would prevent their functioning properly. The machine is driven from a constant-speed motor at the back through gearing, which gives four speeds. If a greater number of speeds is required, a variable-speed motor and control gear can be fitted.

Of the other instruments and tools on the stand which we have described it is unnecessary to say much. There were to be seen, of course, examples of the "Rapidor" sawing machine, and of the Brinell testing machine made by the firm, and also of the "S S" pendulum hardness tester, which is a simple instrument especially designed for use in the shops.

L. M. VAN MOPPES AND SONS.

To those interested in diamond turning tools and the use of diamonds for industrial and scientific

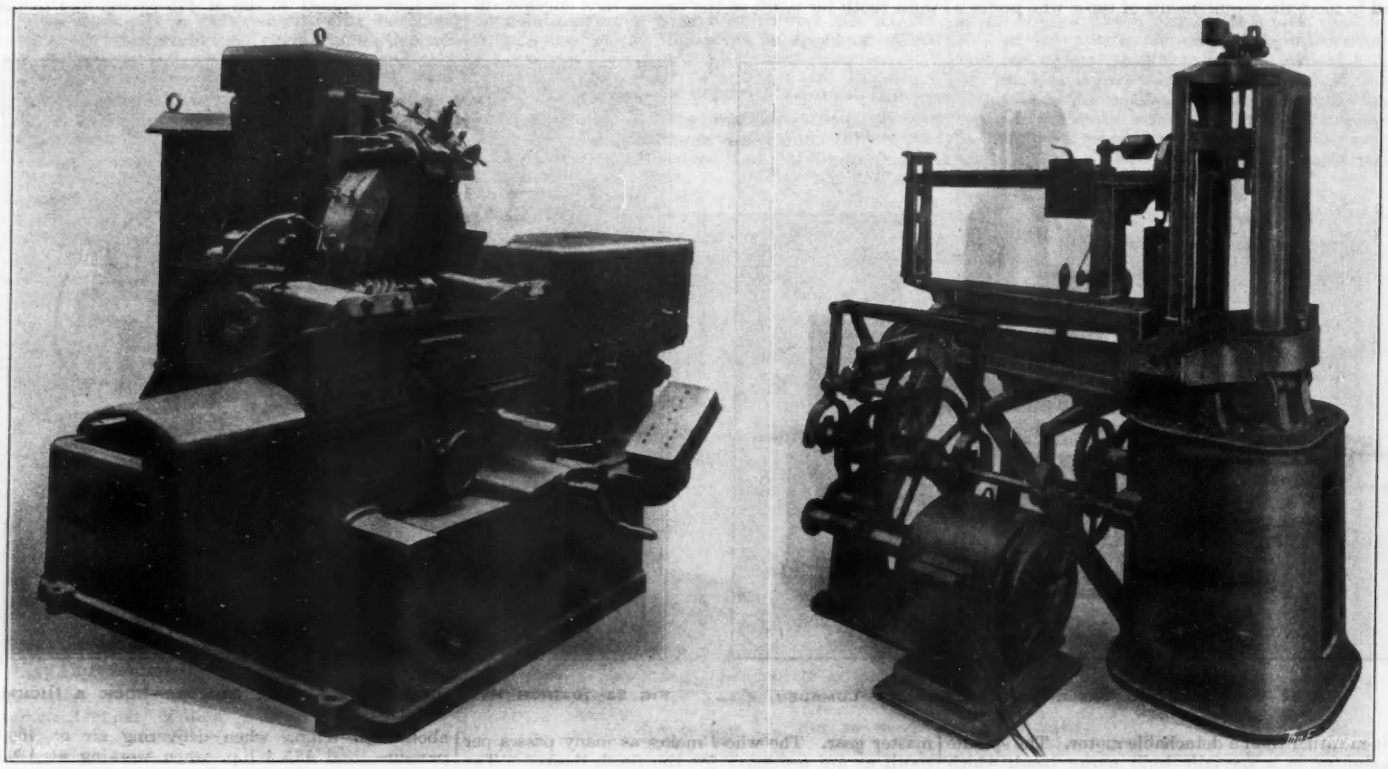


FIG. 55—WORM GRINDING MACHINE—HOLROYD

FIG. 57—OLSEN TESTING MACHINE—E. G. HERBERT

purposes, a visit to the stand of L. M. van Moppes and Sons, of Gardiner House, 10–14, Charterhouse-street, London, E.C.1, was well repaid. The firm had arranged a large selection of exhibits for the purpose of illustrating the properties of industrial diamonds and the different world sources from which they are obtained. Particulars of working costs for diamond turning and wheel truing were made available. Among the engineering exhibits we noted was a small diamond tool which had been removed from a lathe after turning no less than 20,000 motor car pistons, which, we were informed, was still capable of turning a like number. There were also examples of larger oil engine pistons and small connecting-rods, which had been bored and turned with diamond-pointed tools, and all exhibited the characteristic satin finish associated with diamond turning. Other exhibits included diamond cutting and slitting saws, and wheel truing tools and diamond dies for the drawing of fine wire.

A. A. Jones and Shipman, Ltd.

From the extensive exhibits of drilling and grinding machines manufactured by A. A. Jones and Shipman, Ltd., of East Park-road, Leicester, we have chosen for illustration—see Figs. 58 and 59—the large "perfect point" motor-driven twist drill grinder, and a new universal grinding machine, which is also motor driven. The twist drill grinder can be supplied either for motor or countershaft driving, and has a capacity of ¼in. up to ⅞in. It is a development of the smaller ½in. to ¾in. machine which we described and illustrated fully in our issue of April 14th, 1933. Two holders give a range from ¼in. to ⅞in., and a third holder is supplied for drills down to ⅛in. diameter.

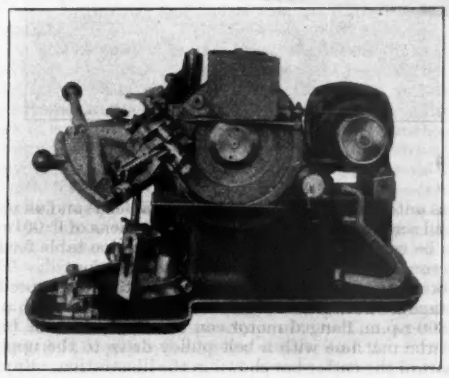


FIG. 59—TWIST DRILL GRINDER—JONES AND SHIPMAN

The machine embodies the same mechanical principles as the smaller model, but provision is made to vary the amount of backing off or clearance angle to suit the different classes of material to be drilled. It can be built either for bench fixing as illustrated or it can be fitted on a substantial column, should this be desired.

Illustration Fig. 58 shows the 24in. by 12in. motor-driven universal grinding machine for external and internal grinding. The wheel head has a self-contained motor drive equipped for either external or internal work, with vertical micrometer adjustment, and a graduated swivelling base movement through 360 deg., by means of which the internal or external wheel can be brought into operation without removing the head. The cross feed to the wheel head is furnished with hand traverse, for dead stop work, or power operation with automatic stop, and has micrometer adjustment to 0·0001in. The work head has a motor-driven, four-speed gear-box with a conveniently placed control lever, and is arranged either for dead centre or live spindle work. It is also mounted on a graduated base with a worm-operated swivelling motion for taper settings. For longitudinal movements a rack and pinion is provided which is fitted to the front of the table. When necessary, the work-head can be fitted with a hollow spindle with a draw-bolt and collet chuck up to 1in. capacity. The centre tailstock is lever-operated, and has an adjustable spring compression for light or heavy work. A swivelling work-table with vertical and angularly disposed tee slots is used. It is reciprocated by a mechanism which incorporates a four-speed gear-box and is driven by a motor mounted inside the main column. It has a cushioning device to absorb the reversal shock, and a dwell motion for grinding to shoulders. There are adjustable stop-dogs to control the length of the table traverse, with a fine screw setting, while the arrangement is such that if needed the table can be traversed past the dogs without altering the setting. Lubrication is effected by oil baths with sight feed lubricators, with visible oil levels, and pressure gun lubrication for special parts. The cooling medium is circulated by an independent electrically driven pump, with strainers and weirs in circuit.

Another interesting machine shown on the same stand was a high-speed bench drill specially built for drilling the fine holes required in fuel injector nozzles down to 0·005in. diameter. It is equipped with a Holman air-driven spindle unit, giving a range of speeds varying from 5000 to 15,000 r.p.m.

Gebruder Heller.

An interesting range of machine tools shown by Leo C. Steinle, Ltd., of 81, Marsham-street, Westminster, London, S.W.1, was the group of semi and fully automatic cold sawing machines designed and built by Gebrüder Heller, of Nürtingen, Württemberg, for which Messrs. Leo Steinle are agents in this country. In Fig. 60 we illustrate the model SS-HA heavy-duty automatic cold sawing machine, which is a development of the builder's earlier type of cold saw, and is made in three sizes to take saws of 14 13/16in., 18½in., and 24in. maximum diameter respectively, and to deal with round bars and other profiles equal to 5in., 6½in., and 8½in. diameter. The clamping and feeding of the material is effected by hydraulic means, and the interlocked controls are designed so as to be foolproof. An electric motor mounted on the back of the machine drives the saw through a Texrope pulley drive, a four-speed gear-box, and a worm and spur gear drive, which is accommodated in the bed of the machine. The feed mechanism comprises a pressure pump and a hydraulic feed cylinder arranged in the work slide. The work is carried between two excentric clamping rollers, the severed piece being ejected from the cutting area by the advancing material. The cutting speeds are geometrically stepped from 39ft. per minute by stages to 98ft. per minute, while the saw feed has a stepless rate up to 20ft. per minute. In the hydraulic system employed in Heller saws, the adjusted feeds are independent of the increase in temperature of the pressure oil. An automatically balancing or regulating pump is used, which apportions the volume of the oil in circuit and by this means adapts the saw feed to the changing cross section of the material which is being cut. Two dials on the machine head show clearly the feed pressure and the clamping pressure. The bar controls are designed for either hand or hydraulic operation. A battery of these saws was shown in operation and the same makers also exhibited a high-speed circular saw bench for the cutting of light alloys, non-ferrous metals, and other like materials, such as vulcanite fibre and bakelite, and a Heller saw-sharpening machine.

Craftplugs, Ltd.

An exhibit which aroused keen interest, alike among machine tool builders and users, and general and constructional engineers, was the display of Craftplug patented fastenings, arranged by Craftplugs, Ltd., of Thames House, Millbank, Westminster, S.W.1. and Letchworth, Herts. By the ingenious application of high-grade rubber for the fixing and suspension of all kinds of material on to various substances, a complete fixing system for both industrial and domestic services has been evolved. To take the case of a machine or engine foundation bolt, it was necessary in accordance with older practice to cast or cut a large hole in a concrete foundation and to allow time for the grouting in and setting of an anchor plate or rag bolt. By using a Craftplug anchor bolt, it is only necessary to drill or cast a hole just large enough for the bolt nut to slip into. As shown in Fig. 61, the bottom of the bolt and the underside of the tightening nut are furnished with conical washers or collars, which under the action of tightening expand the rubber collars threaded on

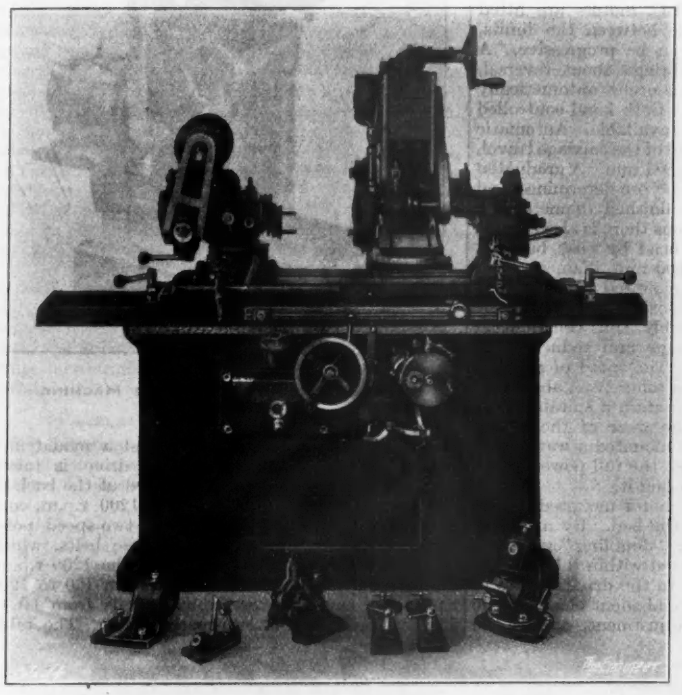


FIG. 58—UNIVERSAL GRINDER—JONES AND SHIPMAN

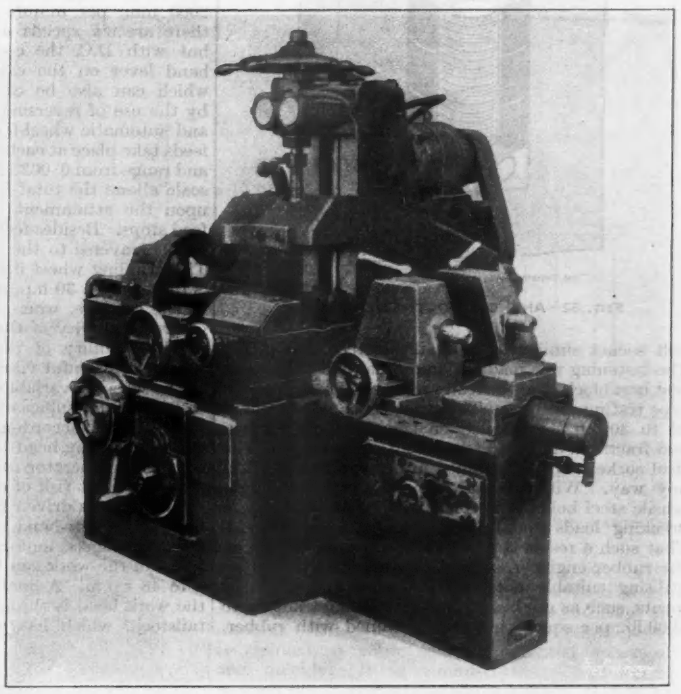


FIG. 60—COLD SAWING MACHINE—HELLER

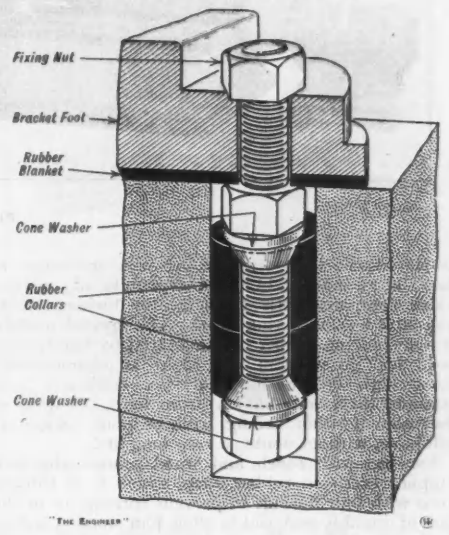


FIG. 61—FOUNDATION BOLT—CRAFTPLUGS

the bolt into the walls of the hole, and so effect an immovable grip. For removal it is only necessary to slack off the tightening nut and lift out the bolt. Fig. 61 shows a standard anchor bolt of this special pattern, while illustration Fig. 62 illustrates a stud bolt, in which the slotted upper nut serves as the tightening member. These bolts are manufactured in standard sizes increasing by $\frac{1}{8}$in. varying from about $\frac{1}{4}$in. up to 1in., or larger, as occasion may demand.

As an example of the strength provided by such a fastening, we may quote the test recently made by Mr. Harry Stanger, A.M.I. Mech. E., of Westminster, and exhibited at Olympia, on a $\frac{7}{8}$in. diameter stud

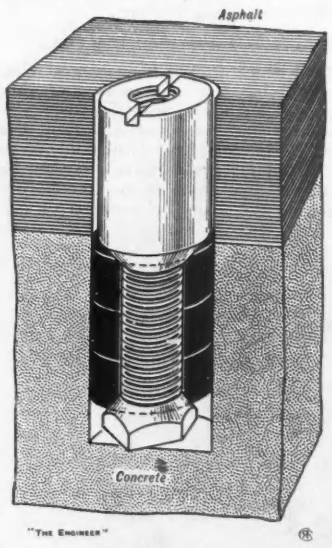


FIG. 62—ANCHOR BOLT—CRAFTPLUGS

bolt socket similar to that illustrated in Fig. 62. The fastening was made in an ordinary cast hole in a cast iron block, and the load was applied in a Buckton type testing machine. The stud, which was made of 25 to 30-ton steel, failed on the threaded portion, and fractured at 14·66 tons about an inch above the stud socket, which remained intact and unaltered in any way. With a rough concrete hole and high-tensile steel bolts, it is conceivable that even higher breaking loads could have been easily withstood. That such a result is possible reflects great credit on the rubber engineer. It is now well known that by utilising suitable accelerators and reinforcing pigments, such as gas black, tensile breaking loads up to 4000 lb. per square inch are obtained with rubber. At the elastic limit such rubber will, according to Geer, store about 14,887 foot-pounds of energy, which compares with 122·5 lb. for hickory wood and 95·3 lb. for spring steel. The special quality of non-splitting rubber manufactured by Craftplugs, Ltd., for its washers and strip is characterised by a high degree of toughness, resiliency, and expandability, and hidden from light, as it is in the case of either ceiling, wall, or floor fixings, it will have, without doubt, a very long life.

For use with coach and wood screws, the firm supplies extruded rubber strip, which is of tubular form with four flutings to prevent turning, or in the case of crumbly material to allow four wooden splines to be inserted into the prepared hole. An advantage of such strip to contractors and shipbuilders is that it can be economically cut to the exact length required for each individual fastening. The firm has also designed suitable square and round boring and jumping tools for plaster, brick, and concrete. Generally, the larger bolt holes can be conveniently made by an ordinary pneumatic drill. For special cases, however, a new form of drill stand has been devised in which the resilent properties of a rubber collar mounted on the drill shank are used to turn the drill at each blow. In this connection the firm is constructing at its Letchworth works an entirely novel form of pneumatic hammer, in which rubber will replace steel springs, and will give, it is claimed an increased number of impact blows and quieter operation. The insulating, sound, and vibration damping properties of the fastenings we have described will, no doubt, suggest further uses for them to our readers.

STEDALL-DOWDING MACHINE TOOL COMPANY.

One of the exhibits on the stand taken by the Stedall-Dowding Machine Tool Company, of 145–157, St. John-street, Clerkenwell, London, was a Naxos-Union roll grinder capable of dealing with rolls up to 12ft. long by 40in. in diameter. This machine, as will be seen from the engraving, Fig. 63, is equipped with a grinding wheel carriage of considerable length, so that the traverse may be smooth and accurate. All the controls are concentrated upon the carriage, and the operator seats himself on a small stool on it in such a way that he can both see the progress of the work and easily reach the controls. The carriage is moved by an electric motor, which, in conjunction with a "doubling" gear, can be so controlled as to give speeds between 140 mm. and 2000 mm. per minute. If A.C. motors are fitted there are six speeds available between the limits, but with D.C. the control can be progressive. A hand lever on the carriage brings about reversal, which can also be caused to occur automatically by the use of reversing dogs. Both hand-controlled and automatic wheel feeds are available. Automatic feeds take place at each reversal of the carriage travel, and range from 0·0025 mm. to 0·1 mm. A graduated scale allows the total feed to be pre-determined and upon the attainment of the finished diameter the feed stops. Besides feed motions there is also a quick power traverse to the wheel head by push buttons. The grinding wheel itself is 600 mm. diameter, and is driven by a 30 h.p. motor mounted near the foot of the carriage, where its disposition will lower the centre of gravity of the assembly, thus contributing to the stability of the carriage and reducing the chance of harmful vibration. The speed of rotation of the wheel is variable over a range from about 600 to 900 r.p.m., sufficient to maintain a suitable peripheral speed according to the wear of the wheel. On the grinding head there is mounted a wattmeter, so that the operator can utilise the full power of the motor without risk of overloading it.

The work is driven from a motor mounted on the floor at the left-hand end of the bed. By means of a variable-speed motor and a "doubling" gear, the speed of the work can be altered within the range of 6 to 48 r.p.m. A final drive to the driving plate in the work head is through special silent chains. The tailstock, which has cross adjustment, carries the wheel-trimming device. A cambering attachment is fitted.

Many other machines were exhibited by this firm, including Lindner thread grinders and Reinecker gear hobbing machines. Some interesting instruments by Carl Mahr, of Esslingen, for testing gears, and Leitz instruments for examining screw threads, also attracted our attention.

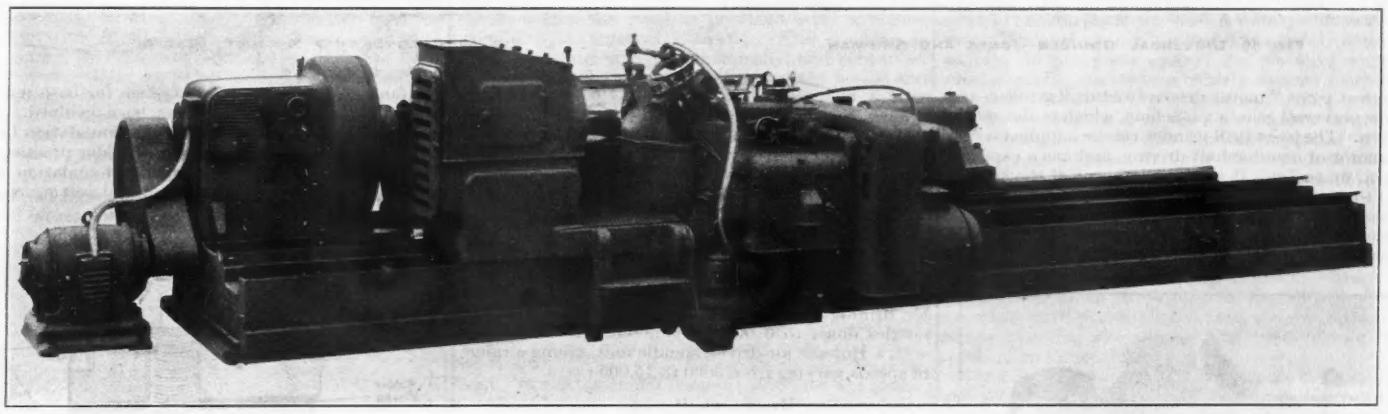


FIG. 63—NAXOS-UNION ROLL GRINDER—STEDALL-DOWDING

GEO. H. ALEXANDER MACHINERY, LTD.

There was a large group of working machinery specially designed for the screw trade on the stand of George H. Alexander Machinery, Ltd., of 82–84, Coleshill-street, Birmingham, all of which machines are made by the firm under licence from the Waterbury Farrel Foundry and Machine Company, of America. Other exhibits included the Sunbeam broaching machine and spline honing machine, and a range of Loewe boring and grinding machines. We have chosen for illustration and description the Deckel F.P.I. universal tool milling machine, which was one of three exhibits made by Frederich Deckel, of Münich, the other two being a pantographic engraving and a die sinking machine, specially designed for the production of moulds and dies for the Bakelite rubber and similar industries. The toolroom milling machine, shown in Fig. 64, is a particularly useful machine, as it is designed to perform with the various attachments belonging to it, a very wide range of duties. As shown in the illustration, it has a vertical milling head with a tilting table. There is also a horizontal arbor with outer support, while other attachments include a machine vice with swivel plate, a slotting attachment, a dividing head designed

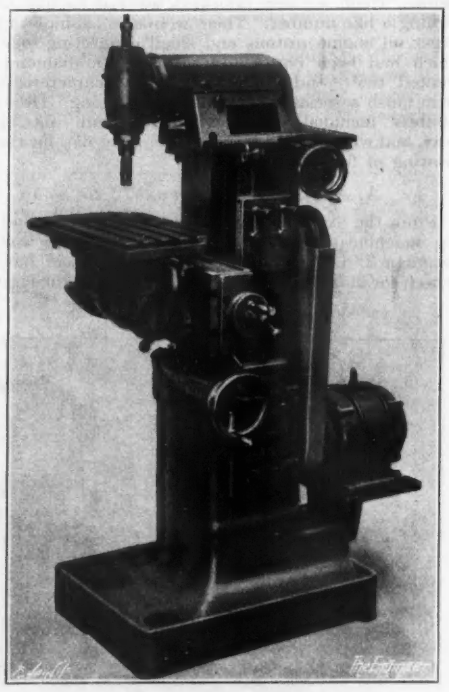


FIG. 64—DECKEL TOOL MILLING MACHINE—ALEXANDER

for direct and indirect spacing, and a mould and punch milling attachment. The drive is taken from a 2 b.h.p. motor which is placed at the back of the machine, and can be either a 1200 r.p.m. constant speed or a 600–1200 r.p.m. two-speed pole-changing motor. There are two vee belts, which transmit the motor drive and with the 1200 r.p.m. motor six speeds varying in steps from 120 to 1200 r.p.m. are available, or twelve speeds from 60 to 1200 r.p.m. with the two-speed motor. The table has automatic vertical and horizontal feeds and all the feed screws have dials permitting divisions of 0·001in. to be easily read. There are six or twelve table feeds according to the design of motor adopted. To obtain specially high vertical cutter bar speeds ranging between 1900 to 6000 r.p.m. a $\frac{1}{2}$ h.p., 2800 r.p.m. flanged motor can be attached to the top of the machine with a belt pulley drive to the upper part of the cutter bar shown in the illustration. From the particulars we have given it will be seen that an unsually large number of machining operations can be quickly and economically carried out. The firm also exhibited a range of hardness testers, sheet metal testers, a roll pressure gauge, and various die heads, taps and chucks.

H. E. WEATHERLEY AND CO., LTD.

Some interesting new machines were exhibited for the first time in this country by H. E. Weatherley and Co., Ltd., of 5 and 6, Chicheley-street, York-road, London, S.E.1. They included a range of horizontal and vertical broaching machines designed by the Oilgear Company, of Milwaukee, America. One of these units was of the "Cyclematic" vertical

hydraulic type, constructed of fabricated steel, with a variable stroke from 30in. to 54in. and a speed range of 18ft. to 32ft. per minute. The machine is fitted with a patented Oilgear pump of about 90 per cent. efficiency, and is so designed that all steps of the working cycle are positively interlocked so that each must be completed or the machine is automatically stopped. The oil system includes variable pressure control by hand or foot pedal and includes a pressure gauge and pressure gauge protector with automatic safety valves.

Another vertical machine was the Oilgear 10-ton all-steel side plate push broaching machine, which is manufactured in Great Britain and has an adjustable stroke of 6in. to 30in. and a variable speed from 8ft. to 35ft. per minute. It is semi-automatic in operation and includes a mechanical broach handling attachment and an automatic broach cleaning device. A horizontal Oilgear machine of twin construction was also on view, which has a stroke of 36in. or 48in., if desired, and a speed variation of 4ft. to 32ft. per minute. The adjustable drive heads are guided on large inserted steel ways and a direct reading pressure gauge indicates the pull in pounds. A selection of broaches was also shown.

On the same stand were a selection of exhibits arranged by the Société Genevoise, Ltd., of 5–6, Brettenham House, Wellington-street, London, W.C.2, which included a No. 6B jig borer with three boring heads arranged in a high-capacity vertical and horizontal drilling and boring machine. This unit, it is claimed, is the largest machine yet constructed to precision standards, and it has a work range of 59in. by 48¾in. by 40in. with a boring capacity up to 8in. A special 32in. dividing table for use with this machine was also shown, which enables machining to be carried out on all sides and on the top face at a single setting. Another noteworthy exhibit was the "Hydroptic A" precision milling and boring machine, which incorporates many new features in design and aroused much interest among the many visitors to this stand. The boring spindle has as many as eighteen speeds ranging from 40 to 1250 r.p.m. and six automatic feeds in both directions, also a sensitive hand feed. The range of work is 37in. by 23½in. A smaller jig boring machine and a Mu 100A gauge measuring machine were also exhibited on the stand.

Charles Wicksteed and Co., Ltd.

Metal-sawing machines of one form or another formed the most prominent exhibits on the stand of Charles Wicksteed and Co., Ltd., Stamford-road

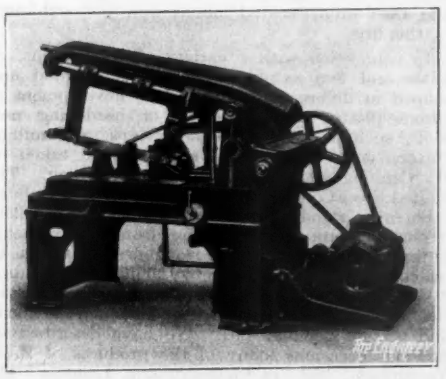


Fig. 65—Hydraulic Resistance Hacksaw—Wicksteed

Works, Kettering, and one of them is represented in Fig. 65.

As will be seen, it is a hack saw of generally normal outward appearance, but it has several peculiarities. The saw is set at a slight angle to the guides, so that the frame is raised during the cutting stroke. This rise is controlled by a hydraulic dash pot, which is equipped with a regulating valve, so that the resistance to rising may be graduated to suit the work in hand. Thus a cut through a wide piece of material naturally requires more pressure on the blade than one in narrow stuff, and the dash pot is consequently throttled accordingly. The valve is provided with a dial marked with positions appropriate for cutting round material. In other words, when it is set at No. 3 the machine will cut best through 3in. rounds and sections of corresponding area. The saw is relieved of load on the return stroke, and the frame is prevented from falling into or out of the cut by a dash pot, so that the saw teeth are not broken by sudden contact with the work or at changes of section. A special device is fitted on the saw frame to ensure that all blades are tensioned alike. The machine is made for cutting up to 10in. rounds.

Drummond Brothers, Ltd.

The stand of Drummond Brothers, Ltd., Ryde's Hill, Guildford, was near the centre of the hall, and on it was displayed a number of the machine tools with which the name of this firm has become familiar, together with several of comparatively novel make; but it is noteworthy that the small lathes through which Mr. Drummond first made his name as an engineer were entirely absent.

Among the novel machines there was the vertical hydraulic broaching machine illustrated in Fig. 66. Like practically every other machine in the Exhibition, it is self-contained, in that it is driven by an electric motor, although its internal transmission is effected hydraulically. The motor is of 12½ h.p. and runs at 1430 r.p.m. By arranging the machine in a vertical posture, a considerable saving in floor space is effected, as compared with a horizontal machine, while the workpiece naturally lies without attachment on the bolster, but yet can be ejected and taken away easily by gravity when finished. The pump, which is driven by the motor and operates the broach ram, is of the reciprocating type, and has positively seated valves, so that the speed of operation is not influenced by the viscosity of the oil. The pump has a variable delivery, and is driven through a two-speed reduction gear, so that an infinite variation of speed of the broach from 0 to 40ft. per minute can be obtained. The load on the broach is registered on a pressure gauge, and a relief valve is provided so that the broach cannot be overstressed. The broach is automatically gripped and released by the pulling head, so that the operator need only thread the work on the end of the broach and pull the control lever. The operation is then automatic until the finished piece is delivered. The cycle can be locked at any given speed and pressure to prevent interference by unskilled operators. The maximum length of broach the machine will accommodate is 50in., with a 48in. stroke. It will take a broach up to 3½in. in diameter, needing a pull of 15 tons, and will accommodate workpieces 15in. wide by 14¾in. high. The floor space required is 57in. by 37in., and the maximum height 130in.

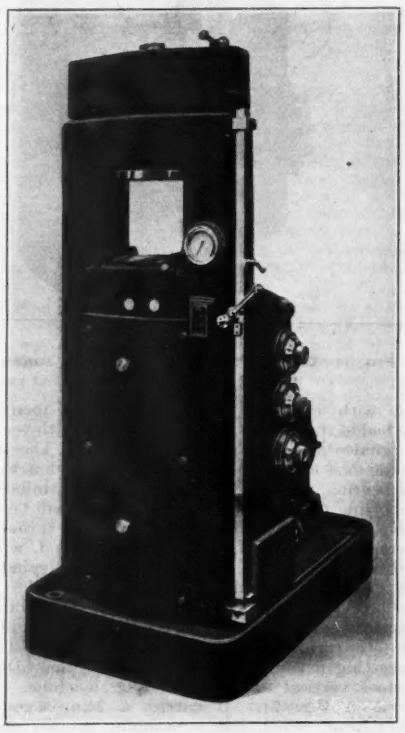


Fig. 66—Vertical Broaching Machine—Drummond

Among the other machines on this stand there were a Maxicut Skimax high-speed lathe with a capacity of 6in. by 12in., with a Timken bearing head, suitable for simple set-ups on light work; a Maxicut rapid production lathe, with hydraulic quick approach and withdrawal actions for the tool combined with cam-operated feeds; a number of other semi-automatic lathes; and a high-speed gear shaper for cutting helical gears.

Luke and Spencer, Ltd.

The high-speed floor grinder, which was to be seen on the stand of Luke and Spencer, Ltd., of Broadheath, near Manchester, has a number of interesting features. It is an entirely new production intended especially for the fettling of castings and the dressing of drop forgings. One of the most interesting points about the design is the arrangement by which the surface speed is maintained. Ten speed changes are available. As the wheel wears down the guard is moved to follow it, and in moving the guard the speed of rotation of the spindle is automatically increased to correspond with the amount the guard has been moved inwards. This arrangement makes the operation of the machine foolproof. For although a wheel can be run under speed, it cannot be run at over-speed. When a new wheel is put on, for instance, it is necessary to bring back the wheel guard, and consequently the speed is automatically reduced.

A five-spindle automatic polishing machine also attracted our attention. It consists of a central roundabout table carrying five work spindles, each having a face-plate on which suitable fixtures can be mounted according to the work in hand. Four motor-driven polishing heads are arranged around the central table, and each polishing head is fitted with rise and fall, cross traverse, and swivel movements, so that for different-shaped articles the heads can be set in the most convenient positions to deal with all the surfaces. The five spindles in the work table are running continuously, but each is fitted with an independent clutch, so that the operator, standing at the front of the machine, can unload one piece and re-load. The depression of a foot pedal then causes the table to move round to the next position, and another finished piece is removed and an unpolished piece substituted.

Benrath Machine Tools, Ltd.

From the large range of British and Continental machine tools which was displayed by Benrath Machine Tools, of 134, Southwark-street, London,

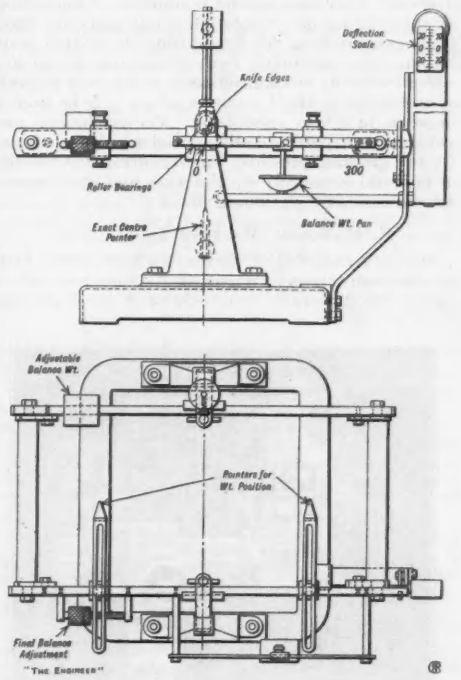


Fig. 67—Static Balancing Machine—Benrath

S.E. 1, we have chosen for illustration one of the range of small static balancing machines manufactured by the firm for general engineering and machine tool work. With such a machine, it is claimed, a rotor can be balanced accurately and quickly. It is mounted on a mandrel or adapter and inserted in the machine. There are roller bearings on either side and the central axis of the balancing mandrel goes through the centre of the machine in line with the knife edges of the balancing cradle. When in position, the heavy point sinks down approximately vertically, but on account of friction in the bearings it does not always acquire the absolutely vertical position. The pointer in the measuring device on the right-hand end of the machine indicates in what position and how much the heavy point deviates from the vertical line in the machine. A

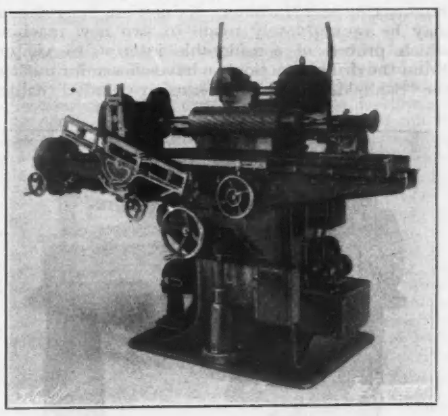


Fig. 68—Grossenhainer Cutter Grinder—Benrath

slight rotary movement of the rotor, however, enables the pointer on the indicator to move to zero, when the heavy point is absolutely vertical below the knife edges. The cradle is then locked by a lever, and by means of a pointer built into the centre of the machine the direction of unbalance is marked. The rotor is then turned through 90 deg. so that the mark made is in a perfectly horizontal plane indicated by pointers on the machine cradle. The machine cradle is again released and the unbalance is weighed in a weighing cup by means of actual weights on a pre-

selected radius, where compensation can be made. The machine is actually a precision weighing machine. In order to speed up working a very sensitive brake is fitted to the machine in the indicator box, while a vertical adjustable weight is fitted to the cradle which enables an increase or decrease in the sensitiveness of the machine to be made, according to the balancing accuracy which may be required for different types of work.

The setting-up time of the machine when changing the work to be balanced is about two to three minutes.

Another interesting tool was the Grossenhainer fully automatic cutter grinder, illustrated in Fig. 68. The machine is universal and is designed to grind slab, side and face milling cutters, also cylindrical and taper cutters, and straight and spiral flutes up to 45 deg. spiral angle. The feed is applied automatically after each second revolution of the cutter, so that during one revolution rough grinding takes place and finishing grinding during the second revolution. The automatic feed motion can be applied either vertically or longitudinally so that it is possible to re-cut the teeth of a cutter which may be broken or worn, in a very short time. The machine is provided with a patented differential regulating device for the grinding pressure, which controls the amount of material removed from the work and compensates for the wear of the grinding wheel.

E. H. Jones (Machine Tools), Ltd.

On the stand of E. H. Jones (Machine Tools), Ltd., of Baldwin-terrace, Wharf-road, Islington, about ninety machine tools were exhibited, most of them

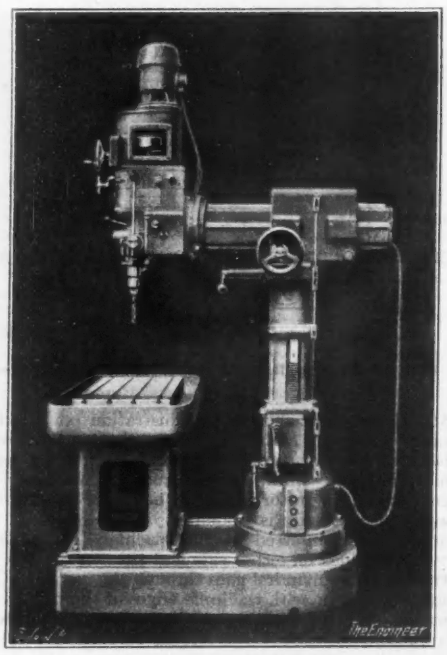


FIG. 69—SAALFELD RADIAL DRILL—JONES

under actual operating conditions. Many of these machines we have described before, either on the occasion of the Leipzig Fair or the Olympia Shipping, Engineering and Machinery Exhibition, but reference may be appropriately made to two new machines which proved of considerable interest to visitors. From the drilling section we have chosen for mention the Saalfeld super-speed sensitive radial drilling

FIG. 70—"KAERGER" LATHE—JONES

machine, a view of which is reproduced in Fig. 69. It has a hand, semi-automatic, or fully automatic feed and infinite speed regulation for spindle speeds from 375 up to 6000 r.p.m., the drilling capacity being ¼in. With hand feed of the spindle only spindle speeds of 6000 to 12,000 r.p.m. can be used. The infinite speed drive mechanism consists of two pairs of hardened and ground steel cones, which are mounted on parallel splined shafts and enveloped by a hardened steel ring, in the manner of a cone pulley belt drive. By moving the cones outwards or inwards from or to each other an infinite spindle speed range is obtained. The drilling head is arranged for both radial and swivelling movements, which are easily carried out. A box table is provided with tee slots and the maximum throat distance is 2ft. 8in. More than usual interest was displayed in the two models of "Kaerger" sliding, surfacing and screw-cutting lathes, one of which we show in Fig. 70. These machines have been specially designed for the use of tungsten alloy or diamond tools. Such tools demand high speeds with complete absence of vibration, which is obtained by a spindle completely relieved of belt

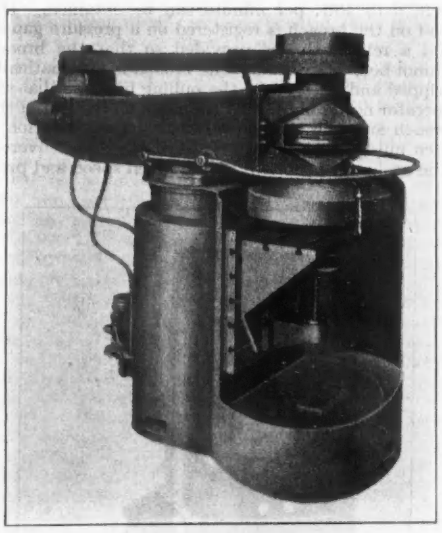


FIG. 71—DISKUS SURFACE GRINDER—JONES

pull, with completely balanced rotary members. The bed of the lathe is of nickel cast iron with vee and flat guides and zigzag reinforcing ribs. The main spindle has adjustable main bearings and a thrust ball bearing, and relief from belt pull is attained by supporting that part of the spindle in a ball-bearing sleeve. The motor drives the gear-box through a Texrope drive and six speeds are provided, with a further six speeds on the back gear. The spindle is furnished with rapid stop motion and the feed gear-box is of the Norton pattern with thirteen stepped speeds. The various attachments permit the lathe to turn out a wide range of work. Other interesting machine tools included the new Diskus all-steel vertical surface grinding machine, illustrated in Fig. 71. It carries a 24in. segmental wheel head, which has a swinging motion and is suited for either production or toolroom work, the capacity of the machine being 12in. by 12in.

Other Makers.

To the exhibits on several stands we have so far paid no attention, not so much because they were not intrinsically interesting, as that we had already described them in our pages before the Exhibition opened, or because insufficient technical information was available. The firm of Noble and Lund, Ltd., of Felling-on-Tyne, for instance, exhibited a number of very interesting machines, all of which, however, have been described at one time or another in The Engineer. Moreover, the exhibits of a number of other firms were of a kind which is unsuitable for a lengthy description, although visits to the stands of the firms concerned were very interesting and instructive. Samuel Osborn and Co., Ltd., of Sheffield, exhibited tools of many kinds from straight carbon steel to "Cutanit," a molybdenum-titanium carbide alloy. The efficiency of the various tools, which included such things as drills and milling cutters, was demonstrated on suitable machines. Files, chisels, drills, reamers, &c., were exhibited in a show case. Tools made of "Rennite" were exhibited by the Rennie Tool Company, Ltd., of Manchester. Rennite has an iron base, and is high in cobalt, tungsten, molybdenum, vanadium, and chromium, and quite high in carbon. The makers claim that they have a material with greater powers than high-speed steel and without the disadvantages of tungsten-carbide tools.

Among those firms exhibiting machine tools which we have not so far mentioned there were Frederick Pollard and Co., Ltd., of Leicester, upon whose stand drilling machines of many kinds were to be seen; and Charles Churchill and Co., Ltd., of Walnut Tree-walk, Kennington, London. The latter firm exhibited Cincinnati milling machines, British-built Churchill-Conomatic automatic machines, Peterman automatics, Cleveland gear hobbing machines, and a number of other tools. Snow and Co., Ltd., of Sheffield, had a number of surface grinders to exhibit. The Brooke Tool Manufacturing Company, Ltd., of Birmingham, showed engineers' small tools, such as high-speed steel twist drills, milling cutters, reamers, slitting saws, vices, jigs, &c. Pumps for the supply of lubricant were also to be seen. Small tools were also exhibited by Wearden and Guylee, Ltd., of Bradford. The firm introduced a new chuck at the Exhibition, known as the "Presto" quick-change collet chuck, which was demonstrated in action on an Archdale drilling machine.

A number of makers showed products closely connected with machine tools. Ball and roller bearings and needle bearings were exhibited by the Ransome and Marles Bearing Co., Ltd., of Newark-on-Trent, the Hoffmann Manufacturing Company, Ltd., of Chelmsford, and the Skefko Ball Bearing Company, Ltd., of Luton. The exhibits of these companies were designed especially to show the application of their products to machine tool purposes. Naturally, firms manufacturing belting were well represented. J. H. Fenner and Co., Ltd., devoted considerable space to a demonstration of the efficiency of the "Z" dressed range of solid woven belts. These belts have every strand of yarn encased in rubber and were introduced in 1930. Leather belting and Vee belts were also shown. Among the different classes of belting exhibited by George Angus and Co., Ltd., of Newcastle-upon-Tyne, there was laminated belting built up from strands of leather and having no fasteners or cemented joints to fracture or cause vibration. The new "Gatex" belting, especially suitable for short-centre, high-speed drives, was also displayed. The W. T. Lambourne Company, of Covent Garden, London, exhibited examples of the belts which it has developed as a result of nearly half a century of continuous endeavour. "Clipper" belt lacing machines and hooks were exhibited by the Selby Engineering Company, Ltd., of 73, Chiswell-street, London, E.C.1. Centralised lubrication systems for machine tools are now becoming common practice. The Enots one-shot system was exhibited by Benton and Stone, Ltd., of Birmingham. Fletcher Miller, Ltd., of Manchester, exhibited a representative range of lubricants for the machine shop, including "Cooledge" concentrated water soluble cutting oil, and Sternol, Ltd., of Finsbury-square, London, showed "Supercut" soluble oil and other lubricants, together with Kwenchoyl, for the quenching of oil-hardening steels, hydraulic oil, and "Cooloricid" for overheated bearings. Allen screws in various forms, such as hexagon hole hollow safety set or grub screws, hexagon hole socket head cap screws, &c., were shown by S. Ralph Golding and Co., Ltd., of 15, Mallow-street, London, E.C.1. Sorwal coolant filters and Dart bronze-seated unions were also exhibited by this firm.

In connection with a variety of applications, A. Shaw and Son exhibited diamonds mounted and shaped in different manners. The development of chrome-plating as a method of hardening new tools, such as gauges, reamers, taps, and milling cutters, could be observed on the stand taken by W. Canning and Co., Ltd., of Birmingham. The United Steel Companies, Ltd., of Sheffield, exhibited "Phœnix" rapid machining steel, which has excellent free-cutting properties, and is free from the reproaches of brittleness and lack of toughness. It can be machined at speeds up to 400ft. per minute. "Wyandotte" specialised cleaners for the industrial cleaning of metal were shown by Henry W. Peabody and Co. of London, Ltd. We have described on previous occasions many of the products of E. L. Youngleson, Ltd., of Chancery-lane, London. The "Noveto" three-jaw universal bench vice and machine vices, the "Ely Versa" vice, and several other devices were to be seen on the stand; Fry's (London), Ltd., of King-street, E.1, exhibited hacksaw frames and blades, reamers, drills, &c. One of the most interesting exhibits on the stand of British Timken, Ltd., was a display of Timken bearings illustrating the development from 1898 to the present day. Alfred Beebe, Ltd., of Wednesbury, showed examples of high-class studs, bright bolts, set pins, nuts, washers, &c. On previous occasions, and particularly at the times of the British Industries Fair, we have described the products of F. Gilman (B.S.I.), Ltd., of Smethwick. The firm exhibited a full range of portable flexible drive tools. It is hardly necessary to write that Tecalemit, Ltd., of Brentford, showed various devices in connection with the lubrication of machinery. The new range of midget radial mechanical pumps is particularly worthy of mention. Petrol-driven auto-trucks were exhibited by R. A. Lister and Co., Ltd., and we understand that six of these vehicles were used by the Exhibition authorities in connection with the arrangement of the exhibits in their places. Various types of petrol-driven trucks were shown by Reliance Trucks, Ltd., of Heckmondwike. Rubery Owen and Co., Ltd., showed pressed steel split pulleys and steel storage equipment. The latest "Arclight" horizontal copier exhibited by E. N. Mason and Sons, Ltd., of Colchester, embodies a number of improvements, while the "New Century" continuous copier has a new lamp movement providing for much faster travel. In addition to these two machines, the firm exhibited a new drafting table. Disc grinders and ring wheel grinders were exhibited by Geo. Jackman Machine Tool Company, of High Holborn, London.

Railway and Road Matters.

THE recent announcement of the L.N.E. Railway that it is proposed to renew 436 miles of permanent way next year shows a considerable advance over the amount done last year.

SOME time ago the Middlesex and Surrey Joint Committee as to Thames bridges commissioned Sir Harley Dalrymple Hay, M. Inst. C.E., to investigate the condition of Richmond Bridge. Sir Harley's report has been received and the Committee has expressed agreement with his recommendations for widening the existing bridge, at an estimated cost of £73,000. The Committee anticipates a 60 per cent. grant from the Ministry of Transport. The present bridge was built 150 years ago.

ACCORDING to the Ministry of Transport railway statistics for August, there was an increase, when compared with August, 1933, of 3·3 per cent. in the number of passenger journeys and of 3·8 per cent. in the receipts from passengers. There was also an increase of 9·0 per cent. in the tonnage of freight carried and of 6·1 per cent. in the receipts from freight traffic. The freight train miles rose by 4·8 per cent., the average train load increased from 121 tons to 123¾, and the net ton-miles per engine-hour from 457¾ to 462¾.

THE chairman of the Stourbridge Navigation writes to *The Times* saying that the Minister of Transport has written to the canal companies intimating that the Canals (Continuance of Charging Powers) Act, 1922, expires at the end of 1935, and if canal companies wish to have power to exceed their pre-war tolls they must apply for a private Act of Parliament in each case. Mr. Collis remarks that the original Act of 1922 would have expired in 1930, but on that occasion the Government included that Act in the Expiring Laws Continuance Act.

THE recent revival of the agitation for the twenty-four hours' notation has apparently been killed by the Government refusing to take action in the matter. In the House of Lords on Thursday, November 22nd, Lord Templemore said that after the experiment made by the British Broadcasting Corporation, the Government came to the conclusion that there was not sufficient evidence of a general public demand for the change to justify taking any action in the matter. To this Lord Lamington retorted that there was a demand for the change, particularly among people interested in the great transport services, who were most vitally interested.

THERE was an unfortunate repetition of the Shepreth level crossing disaster of August 17th, 1928, at Wormley crossing, between Broxbourne and Cheshunt, L. and N.E.R., on Tuesday morning. As at Shepreth, the accident was at an occupation crossing and an express passenger train ran into a motor lorry. The locomotive and some carriages were derailed. At Shepreth the fireman was killed, but in this case both the driver and fireman unfortunately lost their lives. We would once more remark that the users of occupation crossings do so at their own risk; the crossings are provided for their convenience and the companies have no responsibility.

EXPERIENCE during the fog last week led to an official of the Automobile Association stating that it showed clearly that the arbitrary experiments of beacons and herring-bone markings and studs at pedestrian crossings had not stood the test of emergency conditions; the beacons could not be of value unless illuminated, and the marks and studs could not be seen. Speaking at Devonport on Thursday evening, Mr. Hore-Belisha resented this "narrow-minded criticism," and asked that those who formed such judgments should say what they would do. Whilst giving every support to the Minister of Transport in his efforts to reduce the death-roll on the road, we would point out that his own Railway Department would not accept anything for use in the movement of trains that would be no protection in the event of fog.

THREE consecutive stations are named in a recently issued report by Lieut.-Colonel Woodhouse on an accident that occurred on June 21st. They are Bronwydd Arms, Conwil, and Llanpumpsaint. On the morning of the day in question a ballast train came to a stand between the two stations first named to load up some rails. The ganger in charge found that a gang of men who should have come from Llanpumpsaint had not arrived, and he could not therefore commence the work. The line is single, and as the ballast train was in possession of the train staff for the Bronwydd Arms–Conwil section, the ganger saw that the motor trolley with the men could not leave Conwil. He therefore detached the engine and dispatched it to Conwil to fetch them. The men, meanwhile, had arrived at that station, whence, under Rules 215 and 217, the motor trolley could proceed into the Bronwydd Arms section without either train staff or an occupation key, provided a flagman preceded it by three quarters of a mile. The ganger, however, went on, and the trolley was run down by the ballast engine, and the ganger paid for his irregularity by losing his life.

ON Tuesday, November 27th, a meeting of local authorities interested in the proposal to construct a lower Thames Tunnel between Dartford and Purfleet was held at the Cannon-street Hotel. The object of the meeting was to stimulate efforts to bring the scheme to a head. It would cost, it is estimated, about £3,000,000. In a letter to the meeting, Mr. Hore-Belisha, the Minister of Transport, stated that the real question was whether, in view of the present state of public finance and the very heavy calls on the resources both of the county councils and of the Road Fund for works of the highest urgency, many of which were left half finished after the financial crisis in 1931, it was expedient or possible to provide the very large sums needed for the construction of the Lower Thames Tunnel. Resolutions in favour of the tunnel from district councils did not carry very much weight unless they were backed by the keen desire on the part of the county councils to set about the enterprise. When or if those councils sent a recommendation they would naturally, he said, receive every consideration. A resolution was carried to the effect that the need for constructing the tunnel had become more urgent and that it should be constructed at an early date to provide for vehicular and pedestrian traffic from Dartford and Purfleet to relieve traffic congestion in East London, and to relieve local unemployment.

Notes and Memoranda.

AN improved process for obtaining sponge iron by the reduction of pulverulent or crushed ores or ore-coal mixtures and its subsequent desulphurisation while in the hot porous state by means of hydrogen, all in one operation, has been patented in Germany, says the *Iron and Coal Trades Review*. The heat evolved by hydrogen treatment raises the temperature sufficiently to allow the mass to be pressed into an ingot, whose direct production thus saves heat and metal losses.

EXPERIMENTS under local fog conditions have been carried out at the National Physical Laboratory with coloured glass filters for motor car headlights, and have led to the conclusion that the only effect of the use of such screens during fog is diminution of the intensity of the light and consequent reduction of penetration of the beam. The distance of visibility is the same with coloured and colourless glasses, providing the intensity of the light, after passing through the glasses, is the same in each case.

SOME interesting work by means of the oxy-acetylene blow-pipe has been carried out on the Clyde in the shaping of large forgings, one of which was cut from a billet 11ft. 2in. long by 22in. wide by 16½in. thick. In the first instance four cuts were made through the 16½in. thick by 5ft. 7in. long forging at a cutting speed of 16ft. per hour. After the billet had been shaped out it was turned on its side and a shaped cut of approximately 13ft. was made. Varying thicknesses had to be dealt with, the greatest being 18in. The operator experienced no difficulty in the work, and the finish of the cut, even on the 18in. material, was very fine.

AT a meeting of the American Welding Society, Mr. E. W. P. Smith presented a paper on the use of polarised light as applied to welding products, in which he gave instructions for the construction of a simple and cheap polariscope to examine celluloid models of structural elements by polarised light. The more costly polariscopes ordinarily used for this work contain Nicol prisms. Mr. Smith's design utilises a polarising mirror made of several sheets of thin glass with backs painted black. When the models are examined by this instrument the arrangement of coloured lines shows immediately the concentration of stress, and indicates where the structure would be likely to fail in practice.

A NEW type of sulphur burner, invented by I. Bencowitz, of the research department of the Texas Gulf Sulphur Company, has been under trial at a pulp and paper works, says the *Chemical Trade Journal*. A feature of the new burner is that the sulphur is melted and burned in spray form. The results are reported as very satisfactory. Efficiency is high, installation costs reasonably low, whilst starting up from the cold is easy. The particular burner has now been operated practically continuously for eighteen months, producing gas of from 19·5–20 per cent. sulphur dioxide content. A gas of 20·5 per cent. sulphur dioxide content has been made repeatedly for a period of eight hours during the day shift. The sulphur trioxide content of the gas is given as only 0·14 per cent.

FORGED axle shafts made of nickel-chrome steel are the subject of much research work. Most of this relates to the addition of molybdenum, as some forgers claim that considerable advantages accrue, whilst others state that its addition makes little or no difference. Investigations, described by Mr. A. G. Arend in the *Drop Forger*, were carried out to bring this to a definite issue. Specimens from the forged shaft were cut to specific test-length dimensions, and the cutting done transverse to the direction of forging. These were taken before and after heat treatment. Specimens were tested of the metal which had been water-quenched after drawing, and also slow cooling. In making a complete survey of the results obtained, it was found that a better all-round combination of properties was secured when certain small proportions of molybdenum were present, than when nickel-chrome steel alone was used.

IN view of the importance of keeping the oil used in electrical apparatus for insulating and cooling purposes at a high standard of reliability and free from contamination by moisture, the Asea Company, of Sweden, has designed a new oil testing apparatus which is compact and reliable and embodies several improvements. An important feature of the apparatus is the heating chamber for raising the temperature of the oil to be tested above that of the surrounding atmosphere in order to avoid air bubbles and contamination. Another special feature is an automatic overload circuit breaker. The apparatus is designed for 50,000 volts and 50 cycles, it being considered that this high voltage allows of tests giving much more certain results than those obtained with lower voltages. The test transformer is filled with compound instead of with oil. As the compound requires no maintenance, this represents a considerable advantage over oil filling. The metal case housing the complete testing apparatus is of convenient dimensions and provided with swivel wheels to facilitate transport.

REVIEWING present-day electrical instruments in the course of his Presidential Address before the Association of Mining Electrical Engineers, Mr. F. C. Knowles said that for many years tungsten steels were used for permanent magnets in instruments, but with the introduction of cobalt steels many changes in design had taken place. For many purposes these magnets had greater stability, were smaller, and could be cast, and in certain qualities of the cobalt steels could be air-hardened, which was of great assistance to production, as cracking was practically non-existent. Recently two new steels for permanent magnets had been produced, a nickel-aluminium-iron alloy and a nickel-cobalt alloy, both of which had a higher coercive force, although a lower permanence than the cobalt steels at present in use, the maximum energy content being not much increased. It had been the practice to use silicon steels such as Stalloy in moving-iron instruments, instrument transformers, &c., but the introduction of nickel-iron alloys, such as Mu-metal, had made it possible to use about one-eighth of the ampère turns previously employed in moving-iron instruments, while instrument transformers could now be made so accurate that it was very difficult to detect any error.

Miscellanea.

WE regret to note the death of Mr. H. P. Benn, the last survivor of the four brothers who gave the name to Benn Brothers, Ltd.

THE Trinidad Government is reported to have accepted the £813,000 tender of a British firm to construct a deep-water harbour for Port of Spain.

THE Executive Council of the Shipping Federation has elected Mr. B. Sanderson, Chairman of the Council, in succession to the late Sir Frederick C. Allen.

CANADIAN central electric stations generated in September a total of 1,597,283 million kWh, a decline of 33,501 million kWh as compared with the August figure.

A CIERVA autogiro recently gave a demonstration of landing and taking off in the streets of Paris. It took off with a 50 yards' run and when landing stopped within 30 yards.

IT is understood by the *Glasgow Herald* that a group of business men with a capital of about one million pounds proposes to re-establish the manufacture of motor cars in Glasgow or the West of Scotland.

AT the Moscow conference of representatives of the Russian coal industry, it was stated that next year work is to start on fifty-five new pits, including nineteen in the Donetz basin and fourteen in the Kuskecki basin.

FOR the period from January to October this year the value of orders for machinery for the U.S.S.R. from this country was £1,263,614, as compared with £304,395 for the same period last year. Metal orders for the same period this year are valued at £2,928,609.

THE new Albbruck-Dogern hydro-electric power station recently put into operation on the Rhine utilises the 7½ miles of the river from the Koblenz–Waldshut railway bridge down to Schwaderloch-Albbruck. There are three generating sets, which are designed for an output of 32,500 kVA, 10,500 V, 50 cycles, at 75 r.p.m.

IN 1913 there were no known deposits of nickel in the territory of the U.S.S.R. At present they are estimated at 14,200 tons of metal in rich ores and 1,000,000 tons of metal in ores with a low nickel content. The Soviet nickel deposits thus occupy the second place in the world, after those of Canada. This notable increase in the extent of known nickel resources was established in 1934 by the exploration of the Aktiubinsk nickel-bearing locality.

WE are informed that the existing legislation relating to Trade Marks and Patents in Palestine is shortly to be enforced, and all goods entering Palestine and marked "Registered," "Registered Trade Mark," "Patent," "Patented," and the like (even if in a foreign language), are liable to forfeiture at the port, unless they are the subject of a corresponding registration in Palestine. Registration in any other country is insufficient for this purpose.

AN illustrated brochure just issued by the Chantiers et Ateliers Augustin Normand, which were founded two centuries ago, gives some particulars of early ship performances. For example, the three-master "Achilles" (1827), sometimes did the journey from Havre to Brazil in 33 days. In 1835 the steamer "Phenix," of 628 tons and 160 h.p., made the passage between Le Havre and London in 16 hours; and in 1842 the first French screw steamer "Napoleon"—built by Normands—attained on trial a speed of 12·4 knots.

FOLLOWING the conclusion of the Anglo-German Payments Agreement, the Board of Trade has now issued a circular requesting firms in the United Kingdom to supply details of outstanding debts due from German undertakings. Under the agreement referred to the Reichsbank has provided the sum of £400,000 towards the liquidation of outstanding debts, and is to make every endeavour to expedite the liquidation of outstanding debts by the realisation of outstanding German commercial claims on the United Kingdom, whether by a credit operation or otherwise.

THE Tasmanian Parliament has passed a Bill to provide for expenditure of £591,000 by the State Hydro-electric Commission on a new hydro-electric power station to be situated on the Derwent River, south of Lake St. Clair. The demand upon the existing hydro-electric stations at Waddamana and Shannon is already beyond their capacity to supply, and further development elsewhere is necessary. The site chosen is capable of development to 88,000 h.p., but construction will be carried out by stages, as demand requires. The station will be linked up with the existing stations and network by H.T. transmission lines.

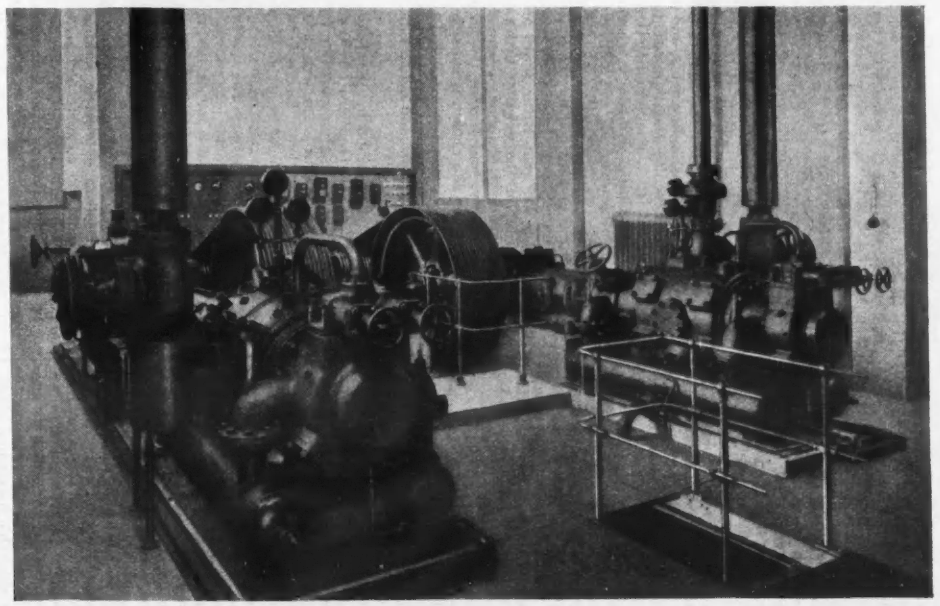
IN a paper delivered before the Junior Institution of Engineers by Mr. R. O. Baird on November 23rd, the various types of housing for radial and thrust and combined bearings were illustrated, and their special features described. The so-called "needle" roller bearing was referred to and the most suitable applications for it stated. In this bearing there is, as usual, an inner and an outer race, the space between the two being occupied by a full row of small-diameter long rollers. It has no cage, and is particularly suitable for oscillating motion and for applications involving continuous cyclic variations in load and speed. It was at first thought that this type of bearing was not suitable for high speeds, but it is now used successfully in the Wilson epicyclic gear-boxes.

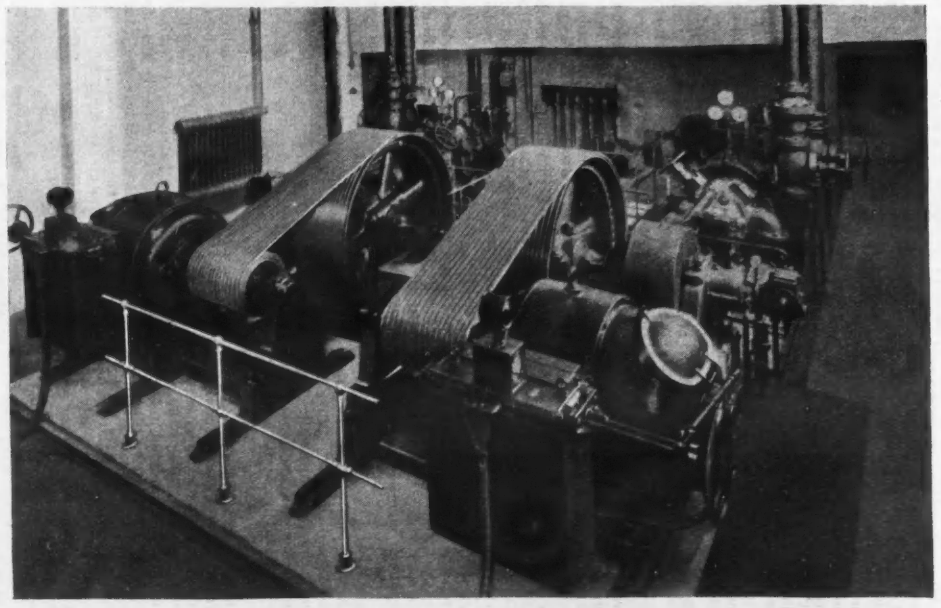
AN interesting strengthening operation was recently completed by means of electric welding. A bin, constructed of reinforced concrete and loaded with linseed, burst, owing to overloading. The problem then arose as to the method of repairing this bin in such a manner that it would be capable of sustaining the horizontal pressure from the increased load of grain, and also to make quite sure that the increase in dead load plus the increase in the grain load would not exceed the safe bearing capacity of the pile foundations. After several tests of welds made under site conditions, it was decided to line the interior of three of the bins to a height of 50ft.–61ft. with ¼in. steel plates, 14ft. by 6ft., welded together, filling in the space between the plates and the existing reinforced concrete walls with sand and cement grout.

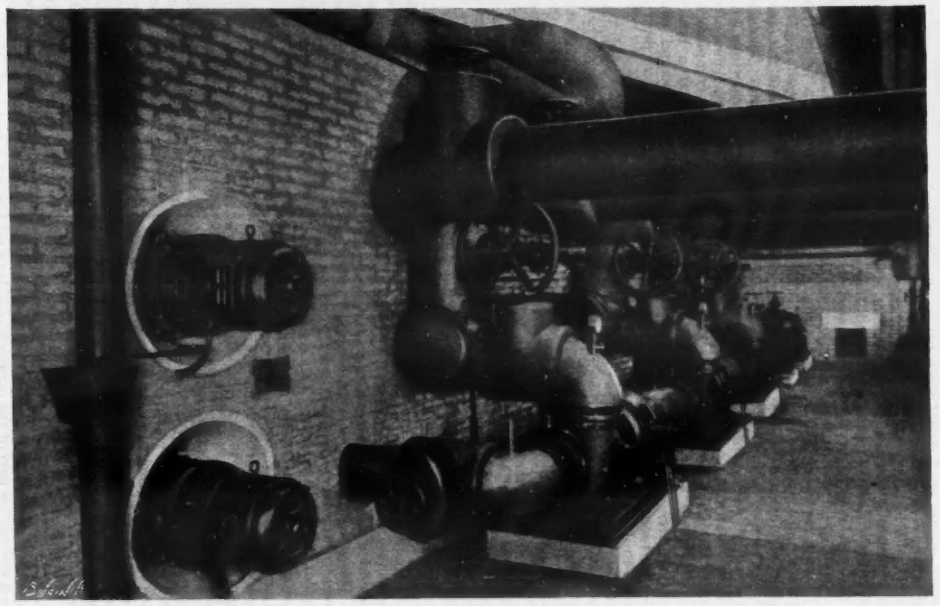
REFRIGERATING PLANT FOR AN OPEN-AIR ICE RINK

SULZER BROTHERS, WINTERTHUR, ENGINEERS

(*For description see page 546.*)







ABOVE:—VIEWS IN THE COMPRESSOR ROOM

BELOW:—BRINE AND COOLING WATER PUMPS

COVER OF COLD ACCUMULATOR TANK

The Engineer

NOVEMBER 30, 1934.

VOL. CLVIII. No. 4116

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THE MACHINE TOOL EXHIBITION.

SURELY never before has such a variety and volume of machine tools been brought together under one roof as the collection which has just been dispersed from Olympia. There were tools so big that one wondered how they had been got into position with the lifting and transporting appliances provided by the proprietors of the hall; smaller machines in endless numbers; ordinary workshop machines; machines of high accuracy for the tool-room; belt-driven machines, electrically driven machines, hydraulic machines; machines for taking enormous cuts at unprecedented speeds, and machines for removing the tiniest fractions of an inch. To stand in the gallery and to gaze down upon the main floor, where possibly not more than half the exhibits were collected, filled one with the conviction that in no branch of mechanical engineering has such steady progress been shown as in that of machine tool making. For even with that bird's-eye inspection one could not fail to observe many noteworthy points in design, as well as the magnitude and apparent complexity of some of the more striking exhibits. On former occasions it has been impossible to gain such general impressions. The stands have been so cluttered up and obscured by large fascias and office structures that the machines themselves could only be seen by close inspection. This year all the central stands were open, and simple standards indicated the names of the makers. We heard no one complain that thereby they were deprived of the "splash" which is so dear to the advertiser; and that the appearance of the Exhibition, from any point of view, was enormously enhanced, cannot be questioned. We may hope that in all specialist exhibitions the same course will now be commonly followed. There is no reason whatever why such shows should be made to look like "fairs," and most exhibitors will welcome the removal of the inevitable expenditure involved in endeavouring to produce something more novel and arresting than that of their competitors.

A display of this kind gives one an opportunity to receive general impressions which are unattainable in factories themselves. There, by force of circumstances, only a proportion, and generally a small proportion, of the machines is new; the others are of various ages, some approaching the time of retirement. In Olympia, on the other hand, we had an epitome, and more than an epitome, of machine tool design as it is at the present moment. It was there possible to see the development of certain lines of thought by all makers. For example, one could not fail to be struck by the preponderance, almost amounting to one hundred per cent., of the individual motor drive. Only a few years ago at an exhibition such as this overhead shafting and countershafting would have occupied as much of the picture as the tools themselves. Here there was little or none of it, each machine of those in motion being operated individually by electric power. The requirements of the Exhibition may have accounted in some measure for that, but since the display did little more in that respect than confirm the experience gained by visits to recent works, it is probable that it really expressed the prevailing tendency of the day. Whether that tendency is being carried too far—the electricity propagandists are extremely clever!—is a debatable point. Another fact which the observer could not miss is the manner in which all the mechanism, as far as the exigencies will admit, is now enclosed. Indeed, in some tools the work itself is almost hidden from view, and the machine minder, if there be one, can do no more than put faith in the tool-setter and have confidence in the trustworthiness of the machine and its equipment. Yet another tendency—though less patent—is the employment of hydraulic pressure for tool operation. There, again, we do not yet know quite where we are. For certain classes of work, grinding provides an excellent example, hydraulic operation has outstanding merits, but for others—let us take planing machines as a single example—its advantages are less obvious. The hydraulic operation of machines is no new thing, but it made no progress till a few years ago. It is probable that it will be carried too far until it has found its right place—the place that makes it the most economical to use for the work that has to be done.

General impressions such as those to which we have referred are not without interest, but a critical survey will prove of greater value to works managers and prospective purchasers. We are attempting to give our readers the benefit of such a survey in a short series of articles on the Exhibition which begins to-day. It is written by a works manager who has had many years of varied experience in machine shops and whose opinion is therefore based on sound knowledge. Mr. Holloway does not describe any of the machines—that has been done fully in our pages—but he discusses certain elements of design from a purely practical standpoint. Not everyone will agree with all he says; but no one will be able to aver that his arguments are based on unsound premises. He writes essentially from the machine shop manager's point of view, with his eye continuously on economic output. We believe that, however acute differences of opinion may be, his articles will be read with great interest. Our object in presenting them is to endeavour to draw from the Exhibition lessons which it is difficult to obtain from mere descriptions alone.

British Civil Aviation and Its Critics.

THE lengthy statement made in the House of Lords on November 21st by the Secretary for Air, Lord Londonderry, will, it may be hoped, do much to counteract the ill effects of the burst of misinformed criticism which descended upon British civil aviation as an outcome of the Melbourne air race. It may not be obvious why the result of that race should afford grounds for a critical attack on British civil aviation. Had the machines which took part in it been predominantly foreign, had the winning machine been other than British or had the winner, while British, won in spite of a poor performance there would doubtlessly have been some reason for criticising the state of civil aviation in this country. Actually, the majority of the machines, engines, and pilots taking part in the race were British, the winners of the speed contest were British and they won by a performance which before the race many people would have declared to be impossible and which in the future may be equalled but is not likely materially to be excelled. Why, then, should the race be used as a ground for attacking British civil aviation? The critics base their case on two main arguments. First, the performance of the winning machine, they say, throws violently into prominence the poor performance, as regards speed, of our regular air service machines. Secondly they call attention to the fact that an American machine, flown by two Dutch pilots, gave a very good account of itself and nearly won the race in spite of the fact that it was a regular air liner carrying passengers, and was not, like the winning British machine, specially designed and built for the contest. It would not be difficult to demolish both these arguments. To the first it might be replied that, self-evidently, Scott and Black's flight was a *tour de force* and could not possibly be repeated as the routine of a regular commercial service. The second might reasonably be countered by the fact that the American "Douglas" machine was of a well-tried design which had previously been thoroughly tested over the bigger part of the route of the race whereas the winning "Comet" machine was of an entirely new pattern and was completed so near the starting date that it was not possible to test it fully. These arguments in reply to the critics might be elaborated but we may, perhaps, more usefully follow Lord Londonderry's example and widen the field to cover British civil aviation generally and its alleged shortcomings.

The general trend of the recent criticism levelled against our regular civil air services is that they are slow relatively to those of some foreign rivals. We need not repeat the arguments on this point which we developed in a leading article on the subject in our issue of November 16th. There is however a passage in Lord Londonderry's speech which deserves to be noted under this head. In the summer of 1933 the great French air transport company known as Air France introduced new liners which performed the journey between Paris and London in about thirty-five minutes less than the 2¼ hours taken by the machines of Imperial Airways. Yet in spite of this acceleration Imperial Airways during the four months from July to October this year carried three times as many passengers across the Channel as did Air France. Speed is not everything even in flying. Beyond a certain point it loses its attraction for the majority of passengers. On short distance routes safety and reliability of service and on long-distance routes, safety, reliability and comfort become more important and attractive than increase of speed. This preference is rational. A traveller from London to Paris is attracted to the air because by flying he will save from four to five hours of the time occupied by the rail and steamer journey. The saving of time is already so great that the saving of an extra half-hour offered by the faster machines is of little consequence to the average traveller. On long-distance routes on which many hours out of every twenty-four are spent in actual flight comfort becomes a predominant factor, and if increased comfort and increased speed cannot be realised in the same machine then increased speed will, in the opinion of most passengers, be the feature to sacrifice. The critics have, naturally, not confined their attack to the comparison between British and French civil aviation. They have made particularly strong play with the state of civil aviation in this country and its condition in the United States. America for obvious reasons is peculiarly well suited to the development of civil aviation, far more so than this country is or ever can be. It is undoubtedly true that there are civil air services and machines in existence in the United States which on the score of speed cannot be approached by any of ours. If we are content to accept that fact without farther examination then British civil aviation must by comparison with the state of the art in America be described as backward and out of date. If however we probe only lightly beneath the surface we find features which reverse the results of the first comparison. American civil aviation has reached its present stage of development by financial methods which would not be tolerated or be possible in this country. On the operational side it has been assisted by a prodigal expenditure of public money on subsidies and air mail contracts. During the seven years from 1927 to 1933 the United States Government gave to the civil air transport companies financial assistance to the extent of 27 million pounds sterling. Encouraged by this lavish bounty to the operators, the aircraft and aero-engine industry afforded a favourable opportunity for the activities of speculators and company promoters. Millions of dollars were poured into it by investors who hoped to realise golden dreams. Both the operating companies and the manufacturers have now been brought to the verge of ruin by the decision of the Government early this year that it could no longer support the financial burden which it was carrying. The

assistance which it had previously given was drastically reduced. A Federal Aviation Commission is now inquiring into the position. Representatives of the air transport industry have already testified to the parlous condition to which it and, through it, the aircraft manufacturing industry have been reduced by the Government's action. The companies, according to one witness, are facing huge monthly deficits with no visible possibility of profit. According to another all the lines will be bankrupt by the end of June next year.

In all countries, our own included, civil aviation is still in the nature of a forced growth. Nowhere, as yet, has it emerged from the green-house stage. It is, however, obvious that in some countries it is being "hardened off" much more effectively and safely than in others. In the United States the growth has been fostered in an over-heated house which the winds of national adversity have now blown down leaving the tender unprotected contents to wilt in the hard climate of the outer world. Elsewhere an almost similar story would seem to be on the point of being told. How long, we may wonder will France, in her unhappy financial circumstances, find it possible to continue to assist her national air transport company on the present scale. According to the latest published figures the sum required by Air France, in order that it may operate just without loss, is £1,300,000 a year over and above its earnings. In this country we have cause for congratulating ourselves that the official policy consistently pursued during the past ten years has been directed not to the attainment of showy results but to laying solid foundations on which our civil aviation industry may one day become self-supporting. The period being occupied in the attainment of that end is proving longer than at one time it was anticipated it would be. Nevertheless there would seem to be undoubted signs that it is approaching fulfillment. With a larger annual ton-mileage than the French, the Dutch or the Italian air transport companies Imperial Airways receives a subsidy markedly lower than that paid to the French, Italian, German or United States undertakings. The most recent figures show that the British company's deficit was at the rate of £450,000 a year. The subsidy received by the company has year by year formed a constantly diminishing percentage of its total receipts. It is now under 45 per cent., a figure very much less than that which can be shown by any Continental competitor. It should be emphasised that this figure has been reached simultaneously with an increased share in the world's air traffic. Clearly, then, British civil aviation does not deserve the censure to which some foolish critics have exposed it. It is being developed on sound technical and commercial lines. Improvements in the time schedules are not being forgotten. They are constantly being made and still more are now being planned. The pursuit of mere speed, however, can, as we know from the experience of other countries, readily prove a costly and even a ruinous policy. Both as taxpayers and as upholders of the country's prestige we are glad to know that neither at the Air Ministry nor in the board-room of Imperial Airways is the recent outburst of criticism in the least likely to alter the policy which has been steadily followed with respect to civil aviation during the past decade, and, in particular, to stampede those responsible for its guidance and execution into a one-sided concentration on the attainment of high speeds.

Machine Tools from the Works Manager's Point of View.

By JOHN HOLLOWAY, M.I. Mech. E.

No. I.

IT was impossible for anyone acquainted with machine tool design and operation to visit the recent Exhibition at Olympia without being impressed by the variety, magnificence, and even beauty of the machines exhibited, and no one will be inclined to stint the praise and appreciation due to both the designers and the manufacturers for the general excellence of their products. Every class of machine exhibited has its points of interest and advantage. In many cases the range of speeds and feeds provided is enormous, and consequently the power of the main drive is higher than anything to which we have been accustomed.

Influence of Improved Cutting Tools.

The cause of the increased power and the wide range of feeds and speeds is obvious. The advent of tungsten-carbide cutting tools has undoubtedly influenced the designers of the majority of the machines to such a degree that most of their pre-tungsten-carbide ideas of powers, speeds, and feeds have gone by the board, and in consequence an almost unprecedented stride in design has been hurriedly taken.

We say "almost unprecedented" advisedly, for in this case history of machine tool design is in many ways merely repeating itself. One remembers the "flutter" caused by the introduction of the early high-speed steel by Taylor-White in 1900. This steel was as much in advance of Osborn's early "Mushet" as tungsten-carbide is in advance of the ordinary high-speed steels of to-day—that is, so far as cutting "speeds" are concerned. The performance of the Taylor-White steel as shown in Paris, and a little later in Glasgow at the 1901 Exhibition, appeared at that time truly marvellous. It was at once seen that the machines of the day were totally inadequate, either in power or rigidity to take anything like full advantage of the new material; more especially was this the case when our Sheffield tool steel makers set to work and quickly produced high-speed steels that easily surpassed the earlier brand in cutting qualities, demanding far higher powers for driving the machines as well as much greater strength in every part.

Quickly our British machine tool makers got right down to the job. The advent of the new cutting steels had caught them unaware. But it is to the lasting credit of the designers and manufacturers that they soon produced the right type of machine to take full advantage of the best cutting steel Sheffield could supply. Machines were improved in every detail. Power, strength, rigidity, ease of operation all received attention, until at last it appeared that the limit had been reached.

But the coming of tungsten-carbide has changed all that. The Machine Tool Exhibition teemed with examples of the degree to which designs have been influenced by the possibilities of much higher cutting speeds, and the results are well-nigh revolutionary, so far as power, speed, and handling are concerned.

The improvements in machine tool design which followed the 1901 Glasgow Exhibition had the effect of making many of the earlier machines not only out of date, but entirely obsolete, and many engineering manufacturers all over the country began to clear out their old tools to make room for the new.

The question naturally arises, Is the 1934 Olympia Exhibition going to have similar effects? Are machines designed, say, six or even four years ago rendered obsolete by reason of the new designs exhibited? If machine tools were like motor cars, *i.e.*, a complete unit in themselves, the answer would easily be in the affirmative, but they are not, excepting in a very few cases, where all the operations on a given piece of work are done on one machine, such, for instance, as small fittings, bolts, &c. The general run of machine tools forms only a single unit in a plant, or in popular parlance a cog in the wheel, and to scrap a whole plant is to most manufacturers a serious consideration, while to the works manager the changing of a "cog" here or there may mean putting the whole wheel out of balance and disturbing that even flow of production which results in the completion of the various units that constitute the finished product for which the plant has been installed. The changing of a single unit, therefore, requires to be carefully considered if the best results are to be realised.

The question of a "well-balanced" plant is of great importance, and we shall return to it later in this series of articles.

General Tendency of Present Designs.

When examining the machines exhibited, and noting the changes in general design, the experienced works manager took a broad view of the Exhibition as a whole, to inform himself of the direction in which the designers have travelled to catch up with, and if possible overtake, the demands for higher cutting speeds imposed by the growing use of improved cutting tools. Those of us who were able to visit the Show were fortunate indeed, but those who were less fortunate and for some reason or another were unable to pay it a visit, it will be some compensation to study closely the excellent Supplements and articles issued with The Engineer during the last week or two. These articles are well supplied with illustrations, which, studied with the descriptive matter, give a good indication of the general trend of the new designs.

Taking an all-round view of the machines exhibited, whether British or foreign, one is at once struck with the similarity of purpose all the totally different designers had in mind when setting out to solve the problem of "increased efficiency." Development has taken place mainly along well-beaten tracks. Certainly there are a few exceptions where new types have been evolved for special purposes, but, speaking generally, improvements have been sought in the direction of individual motor drive, multi-motor drive, power motions in place of hand motions, centralised control, greater range of speeds and feeds, higher power, increased rigidity, and the extended use of ball and roller bearings.

Some manufacturers of precision grinding machines and metal circular saws have developed hydraulic power for feeds in every direction, as well as, in some cases, for moving and clamping the work in position. The results obtained in these examples would appear to justify the innovation, but just how far hydraulic power can with advantage displace the more direct electrical and mechanical powers remains to be proved and will be subject to discussion later.

Most of the machine tool makers have adhered to the direct electric motor drive, coupled with mechanical means for giving a wide range of speeds and feeds. Development has been rather of improvement in details than a change in principle, and one feels that in this respect at least makers are on safe ground. But though there has been little change in principle, there has been plenty of change in design of detail. So much so, in fact, as to remove many of the exhibits far from the category of ordinary types. Examination of a few of these changes may be instructive and will, we hope, indicate the line of development in modern machine tools. It will be interesting to note, in passing, that much of the change we have seen has been, in the main, due to that extra 2 oz. of tungsten carbide attached to the end of a fairly ordinary piece of mild steel.

Motor Drives.—Taking the improvements in the order given above, we will first consider "individual" together with "multi" motor drive. Let us concede at once that direct motor drive to heavy machine tools has been justified by experience. One of the first advantages found is in the lay-out of the machine shop; no longer must machines be placed near to or in line with the main line shafting; the position for the heavy tools can be selected at will; sometimes a position will be selected so as to give the uninterrupted service of the heavy cranes—a very important factor, as machines continue to be designed without a thought as to how work is to be handled—but when deciding the position of any tool, be it heavy or light, it is of equal importance to take care that it comes in line, as near as possible, with the flow of work in proper sequence of operation. If this be done it will ensure a straight flow of work from one operation to another until the finished part is produced, thus obviating that zigzaging course, which means transporting the part up and down and across the shop before it is finished, at the same time adding to the labour and cost of production in no small way.

The individual motor drive at least gives that advantage when laying out the plant. But the advantages are not so obvious when it comes to the smaller size of machines. To fit a separate motor drive to, say, a 6½in. lathe is difficult to justify. It adds to the initial cost, and it is more easily put out of commission than the lathe fitted with a single pulley belt drive. Further, the capital spent on the motor is unproductive a greater part of its time as compared with the motor driving a small group of machines. Again, the total power provided in a number of machines, each having its own motor, is always much greater in the aggregate than is usually allowed for a single motor driving the group. The explanation is simple. The power of a motor put on a single machine must be the maximum that may be required at any time, even if that maximum is only demanded for half-an-hour during the whole day. When estimating the power for a group of machines the fact that all the machines never demand their maximum power at the same time is allowed for. Consequently, a motor having about half the aggregate power of the whole group would be put down, and in practice this has usually been found quite satisfactory.

It can be argued, of course, that frictional losses occur when driving a main line shaft, added to which there are belt losses. The point may be conceded, but what does it amount to? Given a properly aligned shaft running in modern roller or ball bearings and transmitting power to the machines with good belts—not the old rags passing for belts, sometimes seen in machine shops—the frictional losses are really very small, and in all probability are more than compensated for by the saving in upkeep of one motor against perhaps six or eight.

Looked at from the æsthetic point of view, there is much to be said in favour of the all-motor drive. Take the Exhibition, for instance. Row upon row of machines, many of them in motion, but not an overhead driving belt to be seen, it looked a really wonderful show, as it was intended to be. Still, after all, there is a difference between an exhibition and a workshop. The works manager has generally to take the utility and economic point of view in the matter of production at a price.

A great amount of careful study has been put into the design of medium and heavy radial drilling

machines. Many of these have the motor geared direct to the spindle, resulting in very fast and noiseless running. Some of the machines have separate motors for elevating and lowering the radial arm. The arrangement is very simple and convenient, but here again a moment's reflection will show that the elevating motor will be standing idle the major part of the time. In some instances it is safe to say the idle time will be as much as 95 per cent. of the working day. In such instances it is questionable if separate motors for this purpose are justified. At most the elevating of a radial arm is a short operation and is carried out on many machines quite efficiently by mechanical means.

Power Return Motions.—One of the distinctive features of many exhibits is the means provided to reduce the time between the finishing of one cut to the start of another, and to relieve the turner or operator of the task of bringing the tool back to the starting point. Power motions have replaced hand motions in almost every conceivable direction. No longer has the turner or planer to wind back his saddle or tool rest by hand, nor yet the miller or shaper his work table. All this is done for him by power. He merely pushes a button or pulls a lever and back it comes. So quickly does it return that there is some danger of overrunning; hence safety devices are provided to prevent breakdown.

The reasons for these quick-return motions are fairly obvious. There is, of course, the operator to be considered. The question of fatigue has been discussed times out of number, but these multiple power motions, even on small machines, have perhaps become more necessary now that the actual cutting time has been so much reduced. The high speeds at which the newer tools will cut and keep a keen edge over a fairly long period, make it practically imperative to supply power for the equally quick return of the tool to the starting point. Otherwise most of the time saved by the higher cutting speed might be lost in returning the tool.

Great ingenuity has been displayed in devising this power service, as well as in the manner it is arranged. Centralisation of control has been aimed at, so that the operator can stand at a point near the work and be able to control every action of the machine at will.

On heavy or medium heavy machines these power actions will without doubt be appreciated. One remembers the time lost and the effort required to wind, say, a heavy lathe saddle along a long bed or to get the cross saddle of a large planing machine up and down the uprights, or even to bring back by hand the table of a medium milling machine. With the new designs, having power actions at these points, the time saved will be considerable. But on the smaller machine the overall saving is more questionable, and it is not outside possibility that some of the power actions will have to be taken off to bring the price of the tool to a level at which it will be attractive. Furthermore, the shorter the return travel is, the less chance is there of saving either time or preventing fatigue. On reflection it is just likely that the experienced works manager will conclude that the "push-button, pull-lever" idea has been somewhat overdone.

Another aspect of the new machines which merits careful thought is the wide range of speeds and feeds. It must be borne in mind that in all manufacturing works it is becoming more and more customary to put certain classes of work on particular machines. Sometimes it is not only the machine, but the man that counts; at all events, it is only in jobbing or general engineering works that any one class of machine is called on to do a wide variety of work. So that, generally speaking, only the speeds and feeds suitable for the particular job in hand will be used; hence there is no advantage to be gained by having an extraordinary wide range of speeds and feeds attached to every machine.

(To be continued.)

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

UNIVERSITY DEGREES IN ENGINEERING.

SIR,—Having carefully read the series of articles entitled "University Degrees in Engineering," and also the leading article with which you introduced this series, and the correspondence on this subject to which it has given rise, and being personally interested in the observations made in this connection in your columns, both at the present time and two years ago, when you were reviewing the changes in the conditions of granting external degrees by London University, I venture to give my views in support of the letter written by your correspondent signing himself "First-class Hons. B.Sc. (Engineering) London."

It is entirely from the point of view of an engineer engaged in industry and not in an academic or research capacity that I support your correspondent in maintaining that workshop organisation and management, and industrial economics should be comprised among the subjects for a degree, and I would go further and suggest that a knowledge of workshop processes and methods of manufacture should be a *sine qua non* for any young engineer taking a degree for use in industry. Whitworth Scholars doubtless owe their greater success in industry to their more extensive knowledge in this direction.

I am of the opinion that the different conditions under which the various universities grant engineering degrees have no substantial bearing on the ultimate efficiency of the holders, and that the attainment of the young engineer depends entirely on his personal characteristics. Provided his ability and capacity for application and leadership are inherent, the knowledge acquired in obtaining a degree will be an invaluable aid to the young engineer.

In my experience I have had charge or been intimately connected with an Oxford B.A., a Cambridge Second-class Hons. B.Sc., a Leeds First-class Hons. B.Sc., a Newcastle and two Manchester First-class Hons. B.Sc., as well as two London and one Bristol University ordinary pass-degree men. Of these, only the last had the necessary capacity for concentration and hard work which modern conditions in engineering demand, and he is now general manager of a leading Glasgow firm. For a capacity for blowing his own trumpet over the intricacy of the work upon which he was engaged, while at the same time making elementary mistakes in his calculations, the honours must go to this Oxford B.A., and between the others there was little to choose. Half of them have become sales representatives, holding the opinion that in this direction lay the royal road to success in engineering.

There cannot be many engineers who have obtained the London degree solely by private study and evening work, but were it possible to obtain their records, I do not think they would disgrace the university which has thus honoured them. To take my own case, as a young man I entered an engineering works immediately after taking matriculation, and found to my dismay that the demand for munitions during the war prevented my taking the usual course to obtain a degree. Nevertheless, in spite of having to start work at 6 a.m. and closing down, in those days, at six and seven in the evening, by hard work and sheer will power I succeeded in "scraping through" the London University External Degree Course, after an interruption caused by a period of service with the Forces. Since then, presumably by the same determination and effort, I was at the age of thirty in charge of a department of a large works, was placed in charge of design and research by the age of thirty-three, and while still in the middle thirties am now chief engineer of a large engineering works. Such is the record of

ONE OF THOSE DESPISED "EVENING STUDENTS."

November 27th.

SIR,—I would like to correct an erroneous impression created by your article on "University Degrees in Engineering" in November 23rd issue.

You write: "So far, however, as students of engineering are concerned, the necessity for a knowledge of laboratory work practically excludes the possibility of anyone preparing himself independently for the degree examinations entirely by private study. In any event, if such a possibility exists to-day, it will definitely disappear in and after 1936. After that date a regulation will come into force which will require all candidates for an external degree to submit certified evidence that they have carried out a course of work at an approved college or institution."

This gives the impression that all the many deserving candidates who are studying privately for a degree will be barred on completion of their courses from the fruits of their labours.

This regulation, however, only applies to the *final* B.Sc. examination, and not to the *Intermediate*, according to the university authorities. A. H. R.

November 24th.

[We publish this letter with pleasure although it is obviously based on a misinterpretation of our words. We agree that the new regulations for the London external B.Sc. degree which will come into force in and after 1936 apply only to the final and not to the intermediate examination. The University has issued a warning to external engineering candidates that, in and after 1936, anyone taking the final examination who does not submit certified course work in a subject will be considered to have failed in that subject. The regulation will not apply to the intermediate examination. Nevertheless in three of the five subjects of that examination practical tests are applied. These tests are of a kind that make it difficult or impossible for a candidate to prepare himself for them entirely by private study and without a course of laboratory work. Even if he can surmount this difficulty a candidate for the next intermediate examination—in June 1935—should note that at least a year must be allowed to elapse between the intermediate and final examinations. Hence he will be bound to come under the new regulations when he takes his final examination. He will therefore quite certainly not be able to complete his course and earn the fruit of his labours—that is to say obtain the degree—by private study and without attending courses of instruction at an approved college or institution.—ED., THE E.]

TANK TESTS AND THE DELIVERY OF NEW SHIPS.

SIR,—During the past six months there has been an increasing volume of work sent to the William Froude Laboratory connected with new construction. There has been no corresponding increase in staff, and the point has been reached at which it is becoming impossible to carry out test work to a conclusion in the short time which is demanded in almost every case. Accompanying this demand that work should be completed in a short time is the equally emphatic demand that the form and propeller ultimately arrived at as a result of the tests should be more efficient than those which have been previously possible on the "commercial" conditions laid down. This last demand emphatically requires more thought and generally more testing than before, and it will be seen that these two things will not go together. My object in this communication is to ask you to broadcast a general request that in settling the date of delivery for any proposed new ship this date shall be calculated rather from the date at which we complete our resistance tests than from the date at which the contract is signed. The work of the Laboratory will be robbed of its main and greatest use to the industry unless we have a certain amount of time to consider each design. I know of many cases in which a new ship has been under discussion for several months, during which many schemes to give greater economy are discussed with a number of people. A decision to build is suddenly made with a time for delivery, which can only mean uneconomical rushing at the yard and consequent difficulty and sometimes impossibility to allow time to pursue test work until a good result is obtained. If this suggestion is accepted, I am sure it will lead to more satisfactory work being done.

G. S. BAKER,
Superintendent, The William Froude Laboratory.

Teddington, Middlesex.
November 24th.

SIXTY YEARS AGO.

IN 1874 the Midland Railway decided to adopt a revolutionary change in the working of its passenger traffic. It proposed wholly to abolish second-class carriages and to reduce its first-class fares to about the level of the existing second-class fares. This proposal produced much discussion in the public Press and elicited remonstrances from the other great railway companies. The Midland Company refused to be shaken and eventually the other companies united to oppose its policy by agreeing among themselves to follow any reduction of fares made by the Midland Company where they were in competition with it and to continue the running of second-class carriages and reduce the second-class fares. The reasons behind the Midland Company's policy were that by abolishing second-class carriages it would reduce the weight of its trains, simplify its traffic and materially lessen its working expenses. The directors argued that their trains were already too large and heavy, that the most powerful locomotives in the kingdom could hardly keep time with them and that the platforms were too short and the station accommodation deficient. All these troubles, they urged, would be removed by abolishing second-class coaches. In our issue of November 27th, 1874, we discussed these arguments and found them to be very far from satisfactory. The number of second-class passengers carried by the company, it appeared, was more than twice the number of first-class passengers. We pointed out that accommodation would still have to be found for the displaced second-class passengers. The Midland directors argued that the reduction in the first-class fares would result in their travelling in the first-class carriages. This argument, we held, could not be sustained. If there were room for all the displaced second-class passengers in the first-class carriages then the trains could certainly be shortened but there could not be such room unless previously the company had been running three times as many first-class carriages as were sufficient to accommodate the existing traffic. If on the other hand the first-class carriages could not accommodate the displaced second-class passengers the trains could not be shortened and would actually have to be heavier because additional first-class carriages would be required and because first-class carriages were heavier than second-class carriages. Even if some percentage of the displaced second-class passengers found room in the first-class coaches it was doubtful whether any saving would be effected in the length and weight of the trains for to accommodate the remainder additional first-class coaches would have to be provided at the rate of three for every two second-class coaches abolished. The company's proposal, we pointed out in conclusion, amounted to the abolition not of the second-class carriages but of the first-class. The additional comfort and seclusion which passengers paying first-class fares expected to receive would, we said, still be available to anyone who chose to pay the supplementary fare charged for travelling in the luxurious Pullman cars which were run on the company's line. . . . To-day second-class carriages still linger on on some of our lines notably on the Southern Railway's Continental boat trains and on the suburban services of the London and North-Eastern.

BOOKS RECEIVED.

Die Castings. By H. Chase. London: Chapman and Hall, Ltd., 11, Henrietta-street, W.C.2. Price 21s. 6d. net.

Lighting Calculations. By H. H. Higby. London: Chapman and Hall, Ltd., 11, Henrietta-street, W.C.2. Price 31s. net.

Principles of Mechanism. By C. E. Pearce. London: Chapman and Hall, Ltd., 11, Henrietta-street, W.C.2. Price 21s. 6d. net.

Theory of Alternating Current Wave Forms. By P. Kemp. London: Chapman and Hall, Ltd., 11, Henrietta-street, W.C.2. Price 15s. net.

Second Year Engineering Science: Mechanical. By G. W. Bird. London: Sir Isaac Pitman and Sons, Ltd., Parker-street, W.C.2. Price 5s. net.

Problems in Engineering Thermo-dynamics and Heat Engineering. By C. W. Berry, C. L. Svenson, and H. Carlton Moore. London: Chapman and Hall, Ltd., 11, Henrietta-street, W.C.2. Price 7s. 6d. net.

Refrigerating Plant for an Open-air Ice Rink.

WHEN it was decided to construct a new open-air ice rink at Basle, Switzerland, it was considered necessary to install refrigerating plant, so that the working season could be extended as far as possible; but, in view of the facts that during the greater part of the winter little artificial cold is necessary to keep the ice in condition, while the time during which cold is required, at the beginning and end of the season, is comparatively short, it was naturally desired to keep down the charges for refrigeration to a minimum. This has been effected by the contractors, Sulzer Brothers, of Winterthur, by a system of storing cold and by thoroughly insulating the pond.

The pond or rink illustrated below has an area of 65,000 square feet, and is made of concrete with an insulating layer of cork beneath it. It is cooled by means of a grid of pipe work, having a total length of over 51 miles, which is supplied with brine by two electrically driven refrigerating units, each with a rated capacity of 4 million B.Th.U. per hour. We reproduce herewith and on page 542 photographs of some of the more important sections of the plant.

The ammonia compressors are of the double-acting type, and each is driven by a 140 horse-power electric motor. They have stepped pistons, light spring disc valves, and glands packed with self-adjusting metallic packing of a special design. The crossheads work in bored guides and have adjustable slippers, while all the working parts are enclosed to make them dust and oil-tight. Since only the actual cylinders are under ammonia pressure, all the moving parts are easily accessible for inspection and overhaul. A centrally arranged forced lubrication system provides oil for all the moving parts, and the high-pressure cylinders are water jacketed. The compressor room is beneath the grand stand of the rink, so, in order to reduce noise as much as possible, V-belts are used for the speed-reducing drive between the motors and the compressors. It is said that no complaints have been received from local residents, although the machines are frequently run in the night time to take advantage of a cheap electricity supply.

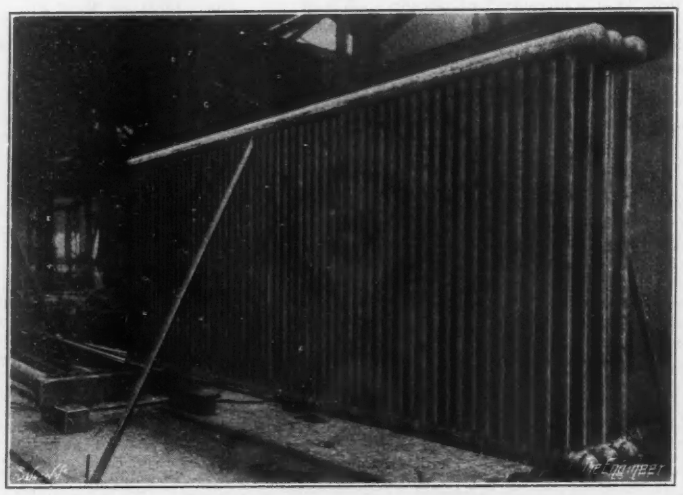
The ammonia condenser consists of a number of small shell and tube elements divided into parallel groups, with the elements of each group connected in series. The advantage of this arrangement lies in the possibility of opening up any one group for cleaning purposes whilst the remainder of the condenser is kept in service. The cooling water for the condenser is circulated by two pumps over a cooling tower erected in the neighbourhood of the refrigerating plant. The cooling tower is of the evaporative type—that is to say, the water is cooled by partial evaporation as it trickles downward and is met by an upward draught of atmospheric air. Natural circulation of the air is relied upon to create the draught, as, although it would be smaller, a tower with fan draught might create a nuisance through noise. A small amount of make-up water is naturally required to balance the evaporation, and is taken from the town mains. The cooled water, which is approximately at atmospheric temperature, is collected in a tank and gravitates to the ammonia condenser.

In order to take advantage of low charges for electric power during off-peak-load times, and to enable the refrigerators to cope with varying climatic conditions, there is a large storage of cold brine. The tank for this purpose has a capacity of 14,500 cubic feet, and in it are installed the ammonia evaporators. By reducing the temperature of the brine in this tank through a range of 18 deg. Fah., it is possible to absorb and store practically the whole of the refrigerating capacity of the plant produced during four hours of normal running. This "cold" can then be drawn upon as required to maintain the sheet of ice on the rink. These demands naturally vary from hour to hour and from day to day, and it may be necessary to run the refrigerators and draw on the storage of cold at the same time to maintain the desired temperature. Hitherto it has generally been the practice to effect the necessary adjustments by means of a number of cocks in the brine piping manipulated more or less by guesswork. At the Basle plant, however, complete control is effected by one hand wheel. The pumps for circulating the cold brine and the devices for regulating the supply of brine to the network of pipes under the ice are installed in the machine-room at the central regulating station, so that there are no outside brine cocks requiring attention.

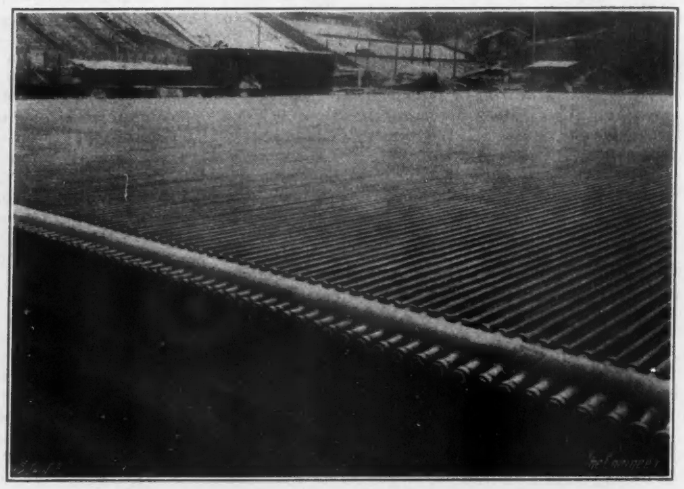
The network of pipes under the ice rink, as we have already mentioned, has a total length of over 51 miles. It is divided up into three sections, each about 200ft. long by 110ft. broad. Each section has its own flow and return pipes for the brine, so that they may be put into and out of service independently of one another. This is of great importance, particularly at the beginning and towards the end of the season, when, in consequence of the higher air temperatures and stronger sunshine, the consumption of electricity for the service increases, while the lesser number of skaters reduces the revenue. It is then usual to shut off part of the rink, by cutting out, say, one-third of the brine grid. The circulation of the brine through the grid sections can be reversed independently, and is effected by three Sulzer centrifugal pumps.

The piping itself is of solid-drawn seamless copper, of Swiss manufacture. Copper was chosen as, at the time when the contract was placed, the price of copper was so little more than that of steel tubing that the extra cost was justified by reason of its greater durability and its much higher scrap value. On account of the great lengths of the individual pipes, they had to be made up on the site of several pieces, and the joints were all made by welding. No soldered joints were allowed from fear of their liability to corrosion under the electrolytic action of the brine. The joints between the grid pipes and the distributing and collecting branches are made with stuffing-boxes, which allow a certain amount of play between the copper bends under the rink and the branches. Each stuffing-box is provided with an opening opposite the end of the copper pipe which can be closed by a cap. Through these openings the interior of the pipes can be inspected, and they can be rinsed through and tested under pressure for leakages.

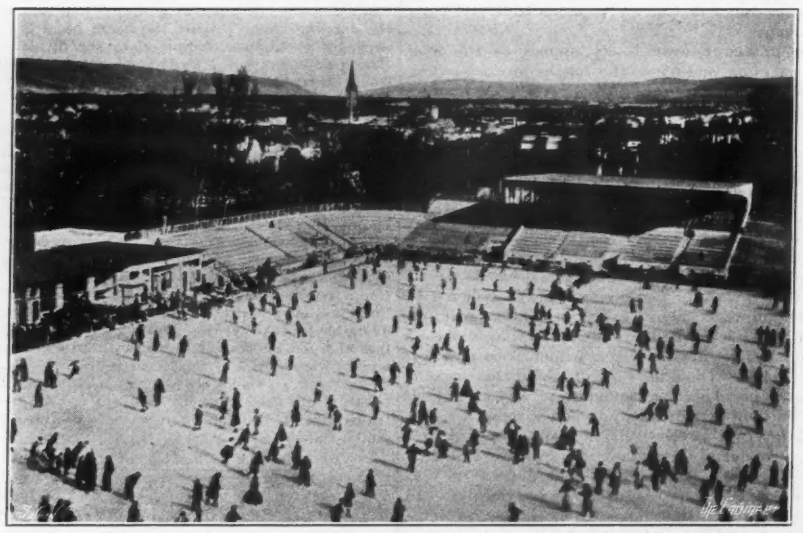
The starting of the plant was slightly delayed by a landslide in the neighbouring St. Margarethen Park, but it was opened to the public on February 17th, last, and since then no troubles have been experienced.



AMMONIA EVAPORATORS



BANKS OF FREEZING PIPES



OPEN-AIR ICE RINK AT BASLE

GERMAN MOTOR CAR EXPORT TRADE.

A DEFINITE scheme for the development of the export trade in passenger cars and commercial vehicles has just been decided upon in Germany, although the trade has already made progress in the present year. Thus, the value of the exports has risen from 19·64 million Reich marks in the first eight months of 1933, to 21·46 millions in the same period of this year, while the imports have advanced from 9·54 millions to 9·63 millions in the same periods respectively. On the balance, the export surplus has increased from 10·10 million marks to 11·83 millions.

The Reich Verband der Automobil Industrie has issued a statement which is freely reproduced in the newspapers, announcing that the efforts hitherto made to expand the export trade have been insufficient to meet the price advantage possessed by the most important competitive industries, especially in consequence of the depreciation of currency. The opportunities for German vehicles must become all the more unfavourable according as other countries promote their exports by means of premiums and similar measures. Though not mentioned individually, the statement is aimed at Italy and France in particular.

In view of this development the Verband states that the German motor car industry has resolved by voluntary co-operation to provide more favourable conditions for the sale of motor cars abroad. For this purpose the industry has established a "compensation fund for the promotion of exports." All the motor car works are stated to have undertaken to contribute to the fund a part of the proceeds resulting from their inland turnover in passenger cars and commercial vehicles for the development of the export trade. In this respect the scheme has been facilitated by the fact that motor car dealers have agreed to accept a graduated reduction in the discounts in recognition of the great national economic importance of the action.

The fund will be brought into activity in exports of all kinds, including orders executed by exporters who will not receive the compensation from the fund, but the actual makers. The manner in which the fund will operate has not yet been disclosed. It is assumed that as the present inland turnover amounts approximately to 400 million marks per annum, a contribution of 1 per cent. will provide a sum of 4,000,000 marks for payment of compensation to makers of exported vehicles.

It is expected that the fund will gradually be extended so as to include spare parts, and also products which have to be purchased by the car makers themselves.

Aerodromes in the Straits Settlements.

THE Annual Report of the Public Works Department of the Straits Settlements refers to the progress made in 1933 with the construction of civil aerodromes at Singapore and Penang.

The former is in course of construction on a site which was formerly the Kallang tidal basin, an inlet off Singapore Harbour, only 2 miles from the business centre of the city. The work in progress includes the excavation of earth filling from the quarry at Jalan Eunos, its transport over 4 miles of double-track 3ft.-gauge railway to Kallang basin, and its deposition therein to reclaim an area of 339 acres suitable for the construction of a modern air port. The whole of the work is being carried out as far as possible by direct labour.

The work of filling commenced in May, 1932. During 1933 1,775,436 cubic yards of filling were excavated and tipped, and by the end of the year approximately 35 per cent. of the work was completed. The monthly output of filling rose from 76,300 cubic yards in January to 184,400 cubic yards in December. The total area reclaimed by the end of the year was 102 acres and the programme of work provides for the reclamation of a further 135 acres in 1934 and the balance in 1935. The cost per cubic yard for the excavation, transport, spreading and levelling of the filling fell steadily from 38·35 cents in January to 23·5 cents in December.

In addition to the landing ground now under construction the civil aerodrome scheme includes a seaplane anchorage with a slipway, wharf hangars, and workshops. A complete scheme for the lay-out of the air port, including the terminal building, hangars, approaches, &c., was prepared during the year and forwarded to the Air Ministry for recommendations and advice. Further action in regard to the construction of these permanent works and buildings is being delayed until approval is received from London.

The expenditure during 1933 was 880,156 dollars, bringing the total expenditure up to December 31st, 1933, to 2,109,258 dollars, or 34 per cent. of the estimated total expenditure of 6,200,000 dollars. The total quantity of filling tipped into the reclamation by December 31st, 1933, amounted to 2,176,657 cubic yards, or roughly one-third of the total estimated quantity required.

Work progressed satisfactorily during the year. Owing to the very soft and unstable nature of the mud which forms the floor of the basin fears were expressed that the floor might not be able to support the weight of filling imposed upon it.

The system adopted of bunding off large areas of the basin and allowing them to dry out and a crust to form before tipping the filling, proved quite successful. During the construction of the bunds, however, the unstable nature of the bed was shown by the fact that the actual amount of filling required per foot of bund was over 400 per cent. more than would be required for a similar embankment constructed on firm ground. Bores sunk at certain points show that the bund filling has penetrated 37ft. below the basin bed level.

A section of the completed area of the reclamation has been topsoiled and levelled off and planted with grass. *Axonopus compressus*, the imported grass recommended for use by the Agricultural Department, shows signs of making an eminently satisfactory surface.

The excavation in the quarry is being carried out partly by electrical excavators and partly by manual labour working on contract piecework rates. The railway transported 2,662,000 tons of earth without congestion, and all plant was maintained and repaired in the aerodrome workshop with a minimum of delay to traffic.

The Penang aerodrome is situated in the padi area of Bayan Lapas, 11 miles in a south-easterly direction from the centre of George Town. Work on the construction of the aerodrome was commenced in March, 1932, and during the year considerable progress was made in bringing the landing ground into condition for use, work being carried out chiefly by departmental labour. Further subsoil drains were put in and the surface dressed and graded where necessary. During the dry weather the surface was hard, but nearly three months of continuous rain, which commenced about the middle of September, rendered the surface too sodden and soft to be safe for heavy aircraft to land on. The ground was tested when in its worst condition by the principal works and buildings officer, Royal Air Force Far East, and declared to be unsuitable for all-weather use. It was decided specially to prepare two landing strips, 800 yards long and 100 yards wide, in the direction of prevailing winds. For this work funds were applied for, and it was intended to do the work this year, removing the unsatisfactory soil, replacing it with selected material and rolling this in. A few light aeroplanes used the aerodrome during the year, starting with the Aga Khan's machine in January and the Kuala Lumpur Flying Club machines spent a week-end on the aerodrome at Whitsuntide.

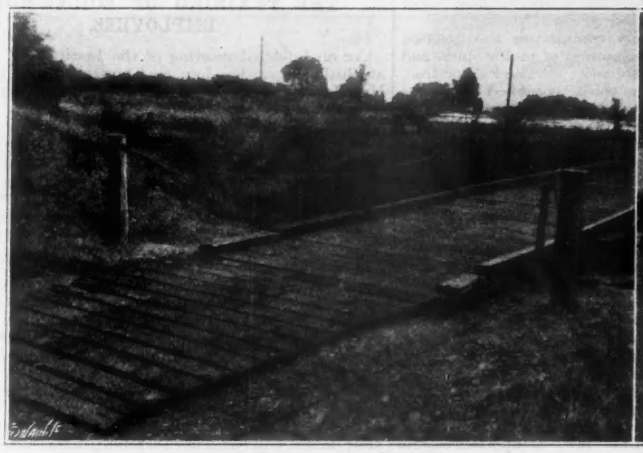
At Nebong Tebal, Province Wellesley, and at Malacca sections of the local golf courses have been levelled for use as emergency landing grounds. They are unsuitable for general use by aircraft and are only to be used in cases of extreme emergency. The Royal Singapore Flying Club completed its fifth successful year. It owns three Moth seaplanes, one flying boat, and one Moth land plane. Arrangements were made during the year for the opening of a flying club in Penang.

A Portable Steel Road.

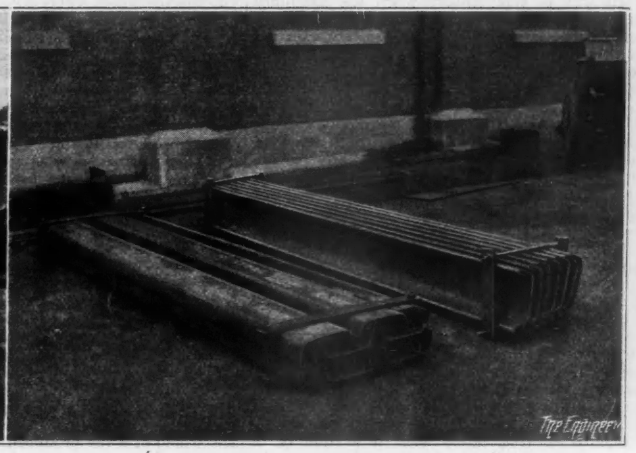
THERE has recently been developed, primarily for military purposes, a form of steel road construction which, it is claimed, can be rapidly laid over soft or marshy ground. The method adopted makes use of a series of pressed steel channels laid transversely to the length of the road. The channels are made so that the flange of one channel interlocks with the adjacent flange of the next. The act of engaging an additional channel with one already in the road is illustrated in one of the accompanying engravings, while in another the channels or troughs are seen laid as an approach road to a temporary bridge.

The channels are made of steel of uniform thickness from $\frac{1}{8}$in. to $\frac{1}{16}$in., depending on the nature of the load to be carried. A form of channel provided with a longitudinal flute down the centre for greater strength is being experimented with, and will probably be superior to the type illustrated herewith. It will be appreciated that within reason the softer the surface of the ground the better, because the channels are then more thoroughly supported and less liable to deformation. The normal forms of temporary road construction used by the Army are those of sleepers or timber planks spiked to longitudinal bearers, or, where circumstances are favourable, the "mix-in-place" process. The new steel construction is claimed to possess the following advantages over the former methods:—(*a*) Greater ease and speed of laying. It can be laid by unskilled labour, and in the dark, rain, and mud. It can, moreover, be jointed up just as fast as the material can be off-loaded from lorries. Only a moderate amount of work on the formation is required. (*b*) Economy in transport. The steel construction has an advantage over all other methods except that of "mix-in-place." An engraving above shows the channels "nested" for transport purposes.

In war the construction described may have several uses other than that for traffic roads, *e.g.*, lorry standings, floors for temporary workshops, stores, &c. tracks for mechanical excavators, and similar purposes. The transverse grooves formed by the joints between the channels, or, in the later pattern, by the flutes in the channels themselves, are found not to be unduly rough for motor transport vehicles at a moderate speed. In practice, however, they would be filled with dirt from alongside the road in order to provide a smooth riding surface. For curves special channels, wedge-shaped in plan, would be supplied. The commercial applications of the new steel road are thought to lie in purposes analogous to those mentioned above. Contractors ordinarily use old railway sleepers for their temporary roads and standings. This method is, of course, cheaper in first cost than the special steel construction described. The latter can, however, be easily taken up and relaid, and, moreover, for an equal area, shows a saving of 50 per cent. in transportation. The inventor is Major H. S. Briggs, A.M.I. Mech. E., R.E., of the School of Military Engineering, Chatham, and the construction is covered by British Patent No. 407,433.



STEEL CHANNEL APPROACH TO BRIDGE



CHANNELS NESTED FOR TRANSPORT

LAYING THE CHANNELS

Electrically Propelled Ships.

How firmly electricity has been established in the shipbuilding industry is shown by the fact that when the design and construction of new vessels are under consideration the use of electricity for auxiliary purposes is now taken as a matter of course. As explained in a paper on the "Generation, Distribution, and Use of Electricity on Board Ship," read before the Institution of Electrical Engineers by Messrs. C. W. Saunders, H. W. Wilson, and Dr. R. G. Jakeman on Thursday, November 22nd, almost all auxiliary machinery from the windlass in the bows, through the engine-room and hull to the steering gear in the stern, is now electrically operated in the most important ships.

Despite the opposition that was met with when the electric propulsion of ships was first proposed, there has been considerable progress in the construction of electrically propelled vessels, both in this country and abroad. In 1931 the power of these ships of all nationalities exceeded 1,000,000 s.h.p., and during that year British yards alone turned out first-class passenger vessels totalling 70,000 s.h.p.

For turbo-electric A.C. propulsion, three-phase turbo-alternators, running at 3000 r.p.m., are generally employed, and although the supply pressure may be as high as 10,000 volts, a pressure of 3000 volts is usually adopted. Generally speaking, the alternators have closed circuit coolers supplied with sea water, as the cooling medium, and to minimise trouble resulting from condensation when the alternators are not in use, small electric heaters, ranging from 2 kW to 3 kW capacity, may be embodied in the machine frames. Excitation is obtained from the ship's auxiliary supply, *viâ* negative boosters or motor generator sets. On oil-electric propelled vessels, the pressure may be as high as 1200 or 1500 volts, and on large vessels several generators are usually connected in series and feed double-armature motors. In the event of a generator or one portion of a motor having to be put out of commission, it is possible by means of suitable switching arrangements to isolate the faulty unit when the vessel may proceed at reduced speed.

The selection of the drive for auxiliary generators naturally depends to a large extent on the type of propelling machinery. When steam is used for propulsion, the auxiliary generators may also be steam-driven, but as oil-driven sets can be run at any time, irrespective of whether the boilers are in service or not, they may well prove to be desirable. The auxiliary generating plant may vary from several 1000-kW generators for a large liner to a 1-kW lighting set for small craft. When oil engine driven generators are employed for propulsion, the auxiliary generators are usually coupled to the same shaft as the propulsion generators, and are equipped with automatic regulators. If direct oil engine propulsion is adopted, oil engine-driven auxiliary sets are employed. Ships of this type have been equipped with waste heat boilers heated by the main engine exhaust and combined with a steam-driven auxiliary generator. To supply power when the auxiliary generators are not running, a small direct driven set is usually installed, and to meet Board of Trade requirements on passenger ships, a small oil engine-driven generator, called the emergency generator, is also installed on the upper deck.

While in the main the construction of ship's generators follows standard practice, care has to be taken to secure accessibility and facility for overhaul on account of the limited headroom and floor space available. All machines must be specially impregnated to withstand tropical conditions and protection must be afforded against

dripping moisture. As the generators may have to run in a fume or oil-laden atmosphere, it is necessary, particularly in the case of D.C. generators, to design the machines so as to prevent the accumulation of dirt and oil at inaccessible parts. Lubrication must be satisfactory at all speeds and with a roll or list of 22½ deg.

Present-day practice has resolved the variety of schemes that have been put forward for ship propulsion during the past twenty-five years into two classes—turbo-alternators with synchronous motors for large ships and oil engines with D.C. generators and motors for small ships; but the line of demarcation between these two categories is not very clear. The maximum horse-power permissible with D.C. is limited by the current to be carried by the commutators control gear and cables. An attempt to bridge over the gap between the two methods is to be found in the suggestion to use oil engines with A.C. generators and synchronous motors, but this proposal has not yet been put to a practical test. For very large ships there is little doubt that the turbo-electric drive is the most suitable at present. Although the frequency at normal speed has usually been fixed at 50 cycles per second for ships built in this country, probably because it is the standard frequency for land practice, there is no reason, having regard to the speed of the turbines and alternators, why any other frequency should not be chosen. In the case of the French ship "Normandie," the frequency will be 81 cycles per second, and the alternators will run at 2430 r.p.m. The principal reason for the choice of the synchronous motor lies in its relatively high power factor which reduces the size of cables and switchgear.

The electrical design of the motors also follows land practice, except for the insulation. Care must be taken in the design of the pole face damping winding which is used for starting and reversing. This winding is not so efficient as a complete squirrel cage, owing to the interpolar gaps, but it can be designed to give sufficient torque for rapid reversals. Ventilation of the motors is effected by separate motor-driven fans through a closed circuit, or the air may be passed through coolers back into the motor room. Heaters are placed in the air circuit to avoid extreme variations of temperature when the machines are standing.

The mechanical design of the motors is characterised by the fact that every part must be as rigid as possible, and yet no weight must be wasted. The lubrication of the bearings has to be fully effective down to very low speeds. In twin-screw ships, two alternators are provided, and for full speed each alternator supplies current to one motor. For cruising speeds it can easily be arranged that both motors are supplied from one alternator, with a consequent increase in efficiency.

Since success has attended the use of oil engines for driving the propellers directly, it is not surprising that the attention of shipowners has been directed to the oil engine electric drive. The addition of electrical transmission has enabled economical values to be selected for the speeds of the engines and propellers, whilst another advantage is to be found in the fact that the engines run in one direction at constant speed and are not subjected to frequent starting and stopping when manœuvring is being carried out. The limitation of D.C. oil electric propulsion lies in the value of the current necessary, since a very high voltage is undesirable. The current necessitates very large commutators and heavy switchgear and cables, and the number of engines required is sometimes excessive. As regards control, the oil-electric system is, of course, far superior to the direct oil engine drive, for in the former case all the speed regulation is obtained by controlling the comparatively small field currents of the generators or motors. Most of the ships already equipped with the oil-electric drive are controlled on the Ward-Leonard system.

Another system which has been proposed is the constant current system, in which a practically constant current flows in the main circuit, speed regulation being obtained by varying the motor feed. As at starting, the motor field is zero, the armature current produces no torque, but as the motor field is strengthened, a torque is developed and the speed of the propeller rises. The generator voltage automatically rises with the propeller speed.

The Work of the Fuel Research Board.

THE report of the Fuel Research Board for the year ended March 31st, 1934, was published by H.M. Stationery Office at 3s. net, on Monday of this week. The year has seen many developments affecting either the direct combustion of raw coal or its conversion into other forms of fuel. All these steps have been closely followed by the Board in order to enable it to adjust its programme to the immediate needs of industry and to ensure that the necessary fundamental investigations are undertaken in preparation for the future.

The Coal Survey.—The increasing knowledge resulting from the examination of the coal seams in the country as they actually occur underground, carried out in the nine laboratories of the National Coal Survey, is playing an important part in meeting the exacting demands now made of coal. The information obtained by the Survey has, the report states, frequently suggested to the colliery authorities modifications of working which increase the efficiency of the pits or improve the quality of the coal as marketed. It has assisted them in deciding whether or not to reopen old districts or to open new districts, and in indicating which seams are the most suitable to work under the present industrial conditions.

Small Coal.—Formerly large lump coal selected by hand at the picking belts was in great demand because it contained the least ash and was relatively easy to handle. Great strides have, however, been made in the purification and grading of small sizes of coal, and now over 77 million tons of coal are cleaned per annum in this country, either by washing or dry-cleaning processes. This is a very large proportion of the small coal raised. The result, the report states, is that there is now less demand for large coal and an increased demand for small coal. This change in public demand, which applies both to domestic and industrial requirements at home, as well as to export coal, has been fostered by a number of factors. Among these factors are the increase in the mechanically fired furnaces, as compared with hand-fired, the utilisation of graded small coal by the gas industry, and the diminished storage accommodation in the modern house or flat. Special attention is being directed by the Fuel Research Station to the purification of washery water used for coal cleaning and to the cleaning of fine coal, both by floatation processes and by dry cleaning. In connection with the demand for small coal, a new problem has arisen, namely, how best to break down large coal to small sizes without undue formation of dust. At the request of the coalowners information is being collected by the Fuel Research Station regarding the present practice in various coalfields.

Coal Carbonisation.—The carbonisation of coal is being studied on a works scale at the Fuel Research Station in three types of retort, namely, in a setting of eight horizontal retorts as used in ordinary gasworks practice, in two narrow brick retorts designed for continuous working, and intended for the production of free-burning smokeless domestic fuel, and in a setting of two vertical chamber ovens. In the horizontal retorts experiments were made on the introduction of steam into the retorts during the last period of the carbonising process. These experiments have indicated that in this way an increase of 10 therms per ton of coal carbonised—over 11 per cent. of the average number of therms produced—can be obtained. The report contains records of successful trials of this method by the Gas Light and Coke Company and by gas undertakings at Cardiff, Wandsworth, and Mitcham. The narrow brick retorts designed at the Fuel Research Station are being continuously used to test the life of this type of retort and to study on a full scale the suitability for low-temperature carbonisation of different varieties of coal suggested by the Survey Committee. The chamber ovens are being used to study the effect of blending various types of coal on the coke produced. This problem, the report states, is of considerable importance in view of the approaching depletion of the best coking coals in some districts, and it is necessary to obtain information which will enable seams of lower coking power to be utilised.

Oil from Coal.—The report summarises the position during 1933 regarding the extraction of motor spirit and fuel oils in this country as follows:—"The lighter fractions of tar, together with the spirit 'scrubbed' from the gas produced by carbonisation, provide an excellent motor spirit, and are the source of the 40 million gallons or so of benzol produced in this country. The creosotes obtained by the distillation of tars from gas retorts and coke ovens can be, and are being, used as fuel oils. The medium fractions of tars produced by carbonising at lower temperatures are even more suitable as fuel oils. In this connection, it is of interest to record that during the year 1933 one home-defence squadron of the Royal Air Force flew solely on motor spirit produced from coal, and in view of the satisfactory results a contract has been placed to cover the requirements of seven squadrons. Also, during the same period, about 2000 tons of oil produced from coal were supplied to the Royal Navy. Trials of this fuel have been carried out both at the Admiralty Experimental Station and on service afloat."

Oil from Tar.—With the methods now in use only 3 gallons of motor spirit can be obtained per ton of coal carbonised. It has been shown, however, that practically the whole of a tar produced at "low" temperatures, and considerable proportions of other tars, can be converted into first-class motor spirit by treating the tar with hydrogen under pressure. The fundamental aspects of the process are being investigated on a small scale at the Fuel Research Station, while the erection of a semi-commercial scale plant is nearing completion. The second-named plant has been designed for a maximum of 400 atmospheres, although it is intended to start at 200 atmospheres. The converter is constructed of British nickel-chromium-molybdenum steel. Its internal dimensions are 16in. in diameter by 13ft. long and the walls are 3in. thick. A maximum wall temperature of 250 deg. Cent. has been allowed for.

Hydrogenation of Coal.—In connection with the direct conversion of coal into oil by the action of hydrogen under pressure, a study has been made of the reactions involved in the early stages of the process. Later stages of the reaction, it is stated, follow on parallel lines to those of the hydrogenation of tar. The development of this process lends importance to the study of the composition of the small amounts of inorganic material, such as the traces of metals naturally occurring in coal, from the point of view of the possible effects these "impurities" may have on hastening the hydrogenation reactions. A spectroscopic analysis of a number of coal ashes is being undertaken on behalf of the Board at the National Physical Laboratory.

Lubricating Oil.—The supply of lubricating oils from home sources is as important, from a national point of view, as a home supply of motor spirit and other oil fuels, and at the Fuel Research Station oils which have lubricating properties, although they are not yet suitable as commercial lubricants, are being obtained from coal products.

Pulverised Fuel.—Experiments with pulverised fuel are being directed mainly to a study of the principles underlying its combustion with the object of developing methods by which coal can be burned in this form in boilers with small combustion spaces, such as Lancashire or marine type boilers. No difficulty is experienced in burning coal containing, say, 25 per cent. volatile matter or over, and several commercial types of burner are available for this purpose. Difficulties arise, however, when the coal contains less than 20 per cent. volatile matter, as is the case with many of the excellent "steam" coals available, especially in South Wales and Scotland, containing about 15 per cent. volatile matter. Another important point, especially for marine purposes, is flexibility as regards load. The demands for steam when manœuvring to enter or leave port vary greatly and with great rapidity. It is also desirable that the burner should be flexible as regards the degree of fineness to which the coal must be ground.

Three types of pulverised fuel burners have been devised at the Station. One of these, the "Grid" burner, is already being manufactured commercially. Consistently good reports are being received concerning industrial application of the burner, and particularly gratifying results appear to be obtained with it when applied to small metallurgical heating furnaces, using a maximum of only 80 lb. of coal per hour. It is claimed that not only is the general operation at least as good as is obtained in similar furnaces with oil, but the fuel consumption is lower in heat units as well as in cost. The largest burner in use at present consumes about 1600 lb. of coal per hour, but an order has been accepted for a plant in which 3 tons of coal will be consumed per hour in a single burner. The other burners are still the subject of research. The Department is endeavouring to keep in close touch with the progress made in the use of pulverised fuel at sea. In this connection a close observation was kept at the invitation of the owners on the behaviour of pulverised fuel plant used by a prominent steamship company during a voyage from London to Liverpool. Experiments are also being continued on fuels consisting of a suspension of coal in oil.

Motor Spirit from Rubber.—Preliminary experiments have been carried out on the possibility of producing motor spirit from rubber by the action of hydrogen under pressure. It is found, it is stated, that rubber is readily amenable to hydrogenation, and, further, that by suitably adjusting the temperature it is possible to produce either motor spirit or lubricating oil. It is realised that the manufacture of these products from rubber would not be economic unless the rubber were available at a very low price. Under the conditions described in the report, a yield of motor spirit corresponding to 50 per cent. by weight of the original rubber was obtained when the reaction temperature was 450 deg. Cent. When the reaction temperature was 350 deg. Cent. the process resulted in the production of a pale yellow viscous oil amounting to 13 per cent. by weight of the original rubber. This oil had properties which would make it suitable as a lubricant. Its viscosity, however, is its poorest quality, but it is suggested as possible that the viscosity of the oil may be improved by some means of refining, such as solvent extraction.

THE TRAINING OF BOILER-HOUSE EMPLOYEES.

AT an informal meeting of the Institute of Fuel, held at Bush House, London, on Thursday, November 22nd, Mr. John Bruce, boiler-house superintendent at the Barking power station, opening a discussion on boiler-house workers, said it had to be admitted that under the present condition of things there are employees in the higher grades of boiler-house work who are of low intellectual standard, and who require almost constant supervision. Continuity of their employment was entirely due to the lack of trained operators, and when that was remedied that type would find a level in the lower grades of boiler-house employment. Such men would obviously benefit little or not at all from a training course. On the other hand, there might be among this class of employee a type of man who could readily understand the simple technical side of his work, but whose practical knowledge was insufficient to decide his actions in the control of such work. At present this workman found it difficult to obtain proper technical instruction. His choice was limited to certain evening classes at the technical schools, and these courses, with one or two exceptions, were not as suitable as they could be. Further, this type of man was engaged on shift duties, and could not therefore attend the full number of classes in a session. There were certain postal courses of instruction which were not, however, altogether satisfactory, nor was the method of training with the aid of text books obtained from the local library or even purchased by the individual.

In the case of the larger plants, the management might consider it an investment if they provided the means and the method whereby these men could be trained. This might take the form of classes which the men attended at the end of their day's work and at which instruction of the technical side of their work was given by one or more of the members of the senior engineering staff. To ensure attendance, it was necessary that the men should be paid for the time occupied at the classes, and, of course, the lecturer must have the gift of imparting his knowledge to others, and also realise that his pupils had not had the advantage of a grounding in fundamentals such as he himself had had. A scheme of this nature had much to recommend it, since the tuition could be connected very intimately with the actual plant which the men were operating. The great disadvantage, however, was that owing to the exigencies of shift duties, the same lecture had to be repeated two or three times, so that all the employees could be progressively taken through the course, and that meant that a course of instruction normally taking six months to complete would take from a year to eighteen months.

Mr. Bruce agreed that the technical and practical training of new recruits to the industry presents many difficulties, and pointed out that the institution of a scheme acceptable to all concerned necessitated the co-operation of interests which, under the present scheme of things, might hold extremely varied points of view.

LLOYD'S LIST.

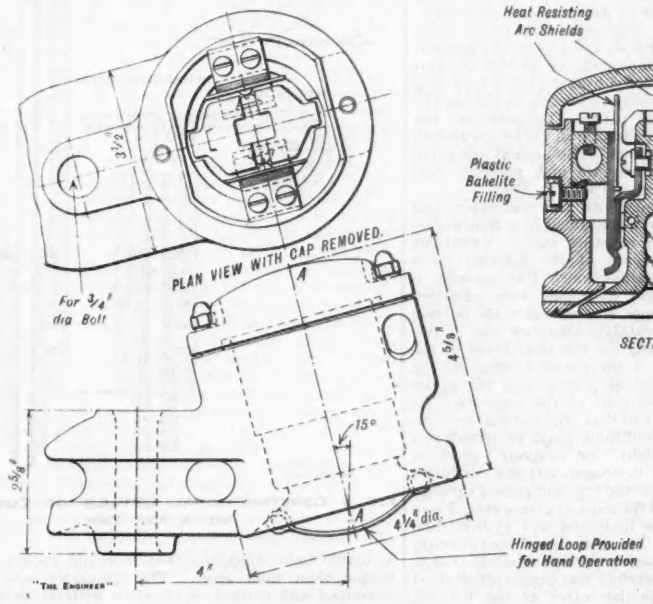
To commemorate its bicentenary, "Lloyd's List" has issued an illustrated pamphlet in which the whole fascinating history of the paper is told. As most people know, the "List" takes its name from a coffee house in Lombard-street, which was owned originally by a Mr. Edward Lloyd and carried his name. Here it was the custom to collect and post up as full and as accurate "ship-news" as could be obtained. One of Lloyd's successors, a Mr. Thomas Jemson, made an effort in 1728 to issue morning and evening papers controlled by a syndicate of "coffee-men," who were to pool their information about ship movements. Jemson's scheme materialised very slowly, but in the very year of his death, 1734, "Lloyd's List" made its first appearance as a weekly publication, and a few years later came out twice a week. Unfortunately, no copies of the earliest issues are known to exist. They were printed on single half sheets and few people were likely to preserve them. Copies were, however, in

existence up to 1838, when all those before January, 1741, were destroyed in the great fire at the Royal Exchange. The subscription was three shillings a quarter. In 1769 the underwriters grew displeased with the management of Lloyd's coffee house and took themselves off to Pope's Head-alley, starting there a "New Lloyd's List." The two papers appeared simultaneously twice a week and the rivalry continued certainly till the end of 1772 and not impossibly till 1785, when Lloyd's Coffee House being closed, the field was left to the (New) Lloyd's Coffee House in Pope's Head-alley. Until 1823 the "List" was managed by the Master of the coffee house, but in that year the Committee of the "List" took the control into its own hands and, at the same time, acquired the business of the coffee house. Any profits from the sale of the paper were divided, as perquisites, between the Secretary—John Bennett—and his chief clerk, who were mainly responsible for its production. In 1837 the Committee took a big step by deciding to seek for public support by enlarging the scope of the paper and publishing it daily. That change may be regarded as a "real landmark in the history of 'Lloyd's List,'" but for long its success was doubtful and the finances continued to cause anxiety up to 1870, when a business-like arrangement was entered into with a printing and publishing house. In 1836 a rival paper, "The Shipping Gazette," was established and after various vicissitudes was in 1916 acquired by Lloyd's, "to be merged in the present 'Lloyd's List and Shipping Gazette.'"

L.T. Distribution Fuses.

LOW-VOLTAGE rewirable fuses of simple design and without a filling powder, but having a rupturing capacity insufficient to warrant their inclusion in our recent series of articles, have been brought to our notice by Switchgear and Equipment, Ltd., of Banbury, Oxon. They can be used in a main distribution line as section fuses or at the terminal points of tappings or in service lines. As shown in the drawing, a strain insulator and fuse plug housing comprise a single piece porcelain moulding. The former takes the full strain of the line and the latter, which houses the fuse, is inclined at an angle, so as to permit, if necessary, of mounting a number of units in tier form, without affecting the ease of removing and replacing the plugs from the ground with the aid of a pole with a screw-thread at the top, as shown in the half-tone illustration. The fuse units can therefore be mounted in the position usually occupied by the strain or shackle insulators and bare conductors are used for the leading in and leading out connections. By the elimination of separately mounted fuse-boxes with their supports, insulated leads, and cable boxes, a considerable saving in first cost is said to be secured. The drawn copper fuse contacts are self-aligning and all metal parts are nickel plated to make them resist corrosion. As the underneath part of the fuse plug forms a bell-shaped guide, it enables the portable operating pole applied from the ground level to enter the screwed plug with ease. Owing to the quick-running thread, two or three turns of the pole suffice to secure the fuse plug to it, and the plug may be removed by giving the pole a slight pull. When replacing the plug the bell-shaped housing serves as a guide, and a key on the plug fits into a keyway on the housing and correctly lines up the contacts, thus enabling the plug to be replaced by giving it a slight push. The design enables a fuse to be removed and replaced with ease with an operating rod up to 20ft. long under the worst conditions. Although the design practically precludes the possibility of unauthorised persons tampering with the gear, provision can be made, when considered necessary, for sealing the fused plug to the porcelain housing.

FUSE-BOX AND PLUG



REWIRABLE FUSE

Steel Hatchway Covers.

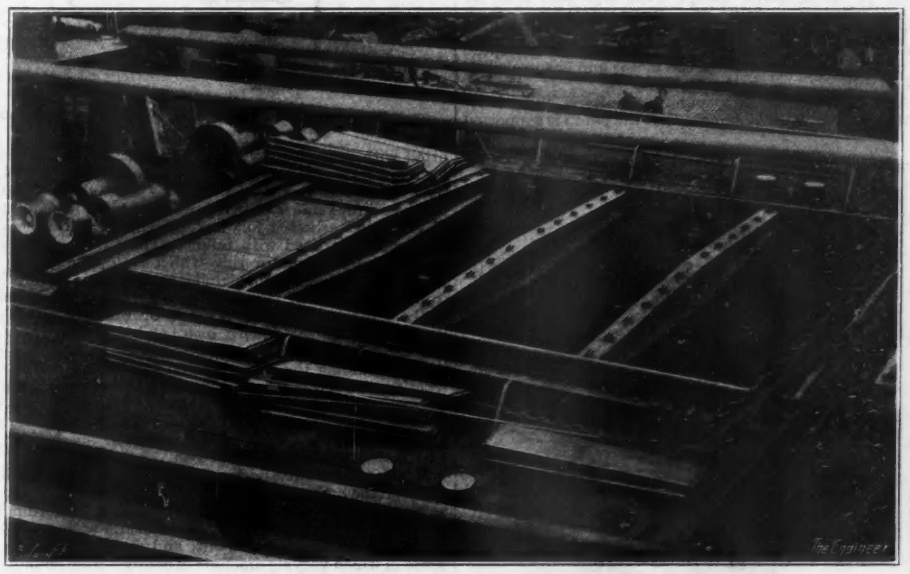
FROM time to time ships have been reported missing after heavy weather, and from the experience of damaged but surviving vessels under similar conditions the opinion is that a large number of these casualities are due to the staving in of hatchway covers. Many cases of vessels having been lost have been directly traceable to defective hatchway covers, including one quite recently. Care is taken in the design of the deck to withstand the large water pressures encountered when seas are shipped, and it is only reasonable that the hatchways should receive similar consideration.

The use of steel hatchway covers has been developed for some time, but the early disadvantages of weight and difficulty of operation, increase of cost, and space required for stowage and difficulties of repair have caused considerable delay in their general adoption.

A new steel hatchway cover, however, the invention of Sir Joseph Isherwood, which, it is claimed, overcomes these disadvantages, has recently been placed on the market, and is manufactured by Clarke, Chapman and Co., Ltd., and Mechans, Ltd., of Scotstoun Ironworks, Glasgow, under licence from Sir Joseph W. Isherwood and Co., Ltd. The cover plates shown in the accompanying illustration are flanged at the sides and ends, and are flat, but where additional strength is required groved plates can be employed. They can be made in small sizes for man handling, or in larger sizes if the winches are used for setting and lifting the hatch covers. An interesting feature of the design is the easy manner in which the covers are locked in position. For about 2in. at each end they are stepped or dished for about ¼in. Between each row of covers running the width of the hatchway are placed two tee-bars, one for each half-width of the hatchway. Plate wedges on the vertical flanges of these tee-bars engage with corresponding wedges welded on the hatchway beams, while the horizontal flanges overlap the stepped ends of the covers.

In the centre, running the length of the hatchway, is an adjustable locking expander. By turning a handle at either end of the hatchway the width of the expander can be varied a matter of 3in. or 4in. By this means provision is made to allow for any inequality in the width of the covers, while the standardisation of the width of the covers is also facilitated. The expander also acts as a filling piece at the centre of the hatchway; while the expansion movement locks the covers, tee-bars and expander positively and firmly to the hatchway beams.

With the covers we have described the ratio between strength and weight obtained as a result of the use of steel is advantageous compared with that operating in the case of wood, resulting in covers which are both strong and light, while their slightly increased first cost should be offset by a longer life. They can be applied to all types of cargo and passenger vessels, and can be easily fitted to existing ships.



ISHERWOOD HATCHWAY COVER

Of the ships equipped with Isherwood steel hatchway covers, perhaps two of the most interesting examples are the ss. "Arcwear" and ss. "Arctees," on each of which the total area of hatch covers is 2660 square feet. One of these installations, that of the ss. "Arcwear," is illustrated herewith. The covers were supplied by Clarke, Chapman and Co., Ltd.

Dual-Market Factories.

DUAL-MARKET Factories were discussed in a paper on "Factory Planning," which Mr. Hal Gutteridge read before a joint meeting of the Institution of Engineering Inspection and the British Works Management Association on November 8th.

The fluctuation of output dictated by the seasonal demand is a matter which comes to a greater or lesser extent within the experience of practically all industries. It raises problems and difficulties which are reflected eventually in a loss of potential profits which, if the plant could have been operated continuously throughout the year, could have been realised. Each year the same cycle takes place. As the time approaches for the demand to start increasing, the selection and training of additional temporary employees and staff, the reorganisation and development of the manufacturing facilities, purchasing, storing, and handling arrangements take place. During the period of increased activity the anxiety and the special supervision required to watch over the insufficiently experienced temporary employees operating unfamiliar machines throw a heavy load of responsibility on the permanent staff. After the peak has passed comes the caring for the organisation capable of handling many times the off-season load.

The employees available for seasonal occupations only cannot be expected to be of the same high calibre as those on the permanent staff, and the rates demanded will be higher. Further, during the off-season period the skeleton staff will necessarily consist of those who are more highly trained and experienced, as they will have to teach the seasonal newcomers and, therefore, the labour costs on that account will be higher also.

A portion of the plant will be idle and earning no profits in the off season, and, therefore, the overhead charges per unit produced will be high.

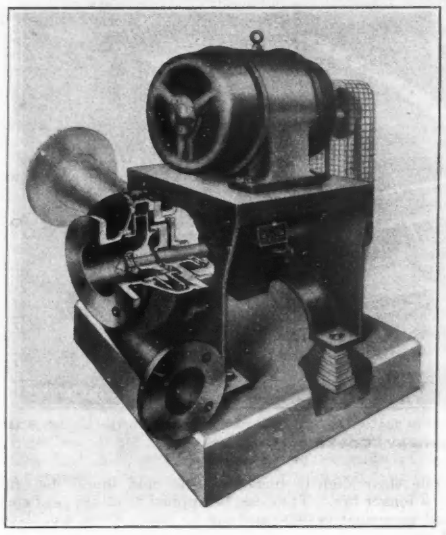
There is a general tendency to-day in the large factories so to plan production that seasonal fluctuations are reduced to a minimum by the introduction of one or more products having different seasonal characteristics from the main product. In the smaller factories, however, it is surprising to find how few are taking advantage of the benefits to be derived from this economic development. Actually, only 2 per cent. of the factories established in Great Britain in 1933 manufactured products for more than one market.

In a new factory, the consideration of this matter is given a foremost place, for each machine and process has to be considered in its dual-duty capacity and types of machines selected which are most suitable to make the proposed products. In an existing factory, where it is desired to introduce a second product, the selection of such a product which, while giving suitably different seasonal characteristics and a sufficient demand, will suit the existing machines, is one which calls for wide experience.

The "Siflex" Pump.

With power taken from the grid supply at 50 cycles periodicity pumps direct-driven by standard electric motors are not always working under ideal conditions of duty, because only one speed—about 1450 r.p.m.—is available. In order to provide a wider choice of pump speeds so that any duty can be met by a standard pump at peak efficiency, Holden and Brooke, Ltd., Sirius Works, Gorton, Manchester, are putting on the market a new range of motor-driven pumps with capacities from 25 to 800 gallons per minute, the principal feature of which is the method of transmitting power from the motor to the pump by means of a V-belt, which enables the speed to be independent of that of the motor and ensures silent operation.

A view of one of these pumping units is given herewith, from which it will be seen that the pump is supported



SIFLEX PUMP

in a cast iron bearing pedestal on the top of which the motor is mounted. The pedestal is of box section to give rigidity, and two widely spaced ball bearings provide a two-point support for the shaft and axial location for the rotating member. A gun-metal lubricator is provided for the bearings. The shaft is of mild steel accurately machined and ground, and the pump impeller is of gun-metal, machined and balanced. It is of the shrouded type, and is hydraulically balanced to eliminate end thrust. The groove in the V-pulley is accurately machined to the correct angle and checked by gauge to give perfect contact, thereby avoiding slip and belt wear.

The pumps are designed so that they can be inspected internally without breaking any pipe joints. The pump speed is adjusted for full diameter impeller and maximum efficiency, and the floor space occupied is considerably less than that of a direct-driven pump set of similar output. Any standard type of motor can be used, and the substitution of a new motor can be effected with the minimum of trouble and expense.

From the annual report for 1933–34 of the Road Fund, which has just been presented to Parliament, it appears that the total payments into the Motor Tax Account at the Bank of England were £31,577,716, as compared with £28,702,370 in the previous year. Under the Finance Act, 1926, one-third of the net proceeds of licence duties on motor cycles and vehicles taxed on the horse-power basis is retained by the Treasury, and the sum actually retained for the year under review was £5,200,000. During the thirteen years 1921–1933 the number of motor vehicles has grown from 873,700 to 2,282,000, and the number of driving licences from 1,106,000 to 2,947,000. Gross receipts have increased from £10,042,000 in 1921 to £28,357,000 in 1933. It is estimated that the figures for 1933 represent one motor vehicle for every twenty persons in Great Britain and one driving licence for every fifteen persons. The total length of public highways in Great Britain is 177,822 miles—152,273 miles in England and Wales and 25,549 in Scotland. Grants made for street traffic signals amounted to £164,441, as compared with £88,343 in the previous year. The number of installations made was 422.

High-Pressure Plant for Experimental Hydrogenation Processes.*

By A. T. BARBER, B.Sc. (Eng.), M.I. Mech. E.,† and A. H. TAYLOR, B.Sc. (Eng.), A.M.I. Mech. E.‡

(*Concluded from page 524.*)

Small-scale Plant for Coal.

Some preliminary experiments were carried out in the Bergius plant in which a charge of coal was placed in one of the converters and hydrogen under pressure was passed through it, the object being to collect separately the products formed during different stages of the thermal decomposition and hydrogenation, and to study the rates of the reactions concerned. The Bergius plant proved unwieldy for this work, which required particularly accurate measurements. A suitable plant was accordingly designed and constructed at the Fuel Research Station.

The mild steel converter No. 6, shown in Fig. 4, is similar to the 2-litre converters already described, but is fitted with a mechanically driven stirrer and with means for allowing a continuous gas flow through the vessel and removal of the vaporised products. The gland packing for the stirrer shaft is in two parts, consisting of five turns of graphited asbestos followed by nine turns of plaited leather impregnated with tallow. The two packings are separated by a lantern ring which is supplied with oil from a reservoir maintained under pressure by a connection from the hydrogen supply line. This has proved perfectly satisfactory. This plant is operated at pressures up to 3750 lb. per square inch, and a temperature of 840 deg. Fah., each experiment occupying about sixteen hours, including the time required for heating up to the reaction temperature. Heating is effected by enclosing the converter in an electric furnace, formed in halves, in which it is possible to maintain a desired temperature along the whole length of the reaction space with a maximum variation of 4 deg. Fah.

Mention has already been made of the appreciable effect on the hydrogenation of coal of very small quantities, as low as 0·01 per cent., of certain catalysts. Accordingly, to obtain comparable results, experiments with no added catalyst were first carried out, and were followed by a series in which varying amounts of catalyst were employed. The importance of this procedure was emphasised when a repetition of a non-catalyst experiment was attempted after a trial with 1 per cent. of a tin compound. It was found impossible to reproduce the original results, even with a new stirrer, until $\frac{1}{32}$ in. of metal had been removed from the internal surfaces of the converter.

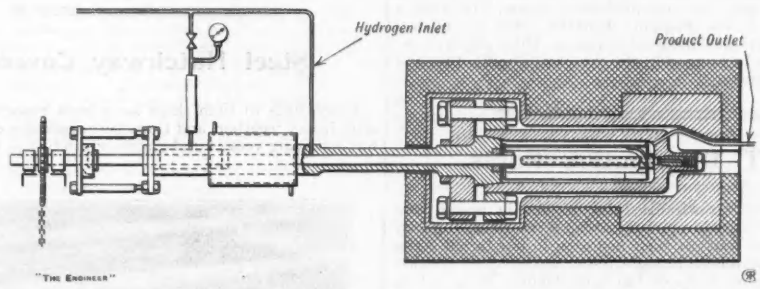


FIG. 4—CONVERTER NO. 6 FOR BATCH COAL EXPERIMENTS WITH CONTINUOUS GAS FLOW

Small Continuous Tar Plants.

Converter No. 4.—Although a number of tar hydrogenation experiments have been carried out in Bergius converters, it was soon found that they were not the most suitable type for this work. A small continuous converter (No. 4) was accordingly designed and erected in 1930–1, together with the necessary auxiliary plant. The converter, which was operated in a vertical position, was of mild steel, 4in. in diameter by 1ft. 8in. long internally; the walls were $1\frac{1}{4}$in. thick, while the end covers, $2\frac{3}{4}$in. thick, were held in position by six bolts $1\frac{1}{2}$in. in diameter. Double-cone joints were employed, as in the Bergius converters. Heating was effected by completely enclosing the converter in an electric furnace formed in halves, the division being in a vertical plane. Temperature was measured by thermo-couples situated in pockets attached to one or both of the end covers. The normal operating conditions were 3000 lb. per square inch pressure, and temperatures between 830 deg. and 900 deg. Fah.

In most of the experiments with this converter, and subsequently, the catalyst was contained in a thin-walled chamber inside the pressure-resisting walls. Variations were made in the arrangement of the internal parts and in the inlet and outlet connections. For instance, in several experiments, tar and hydrogen were admitted together through the top flange, and carried to the bottom by an internal pipe. The catalyst chamber was in two parts, the lower portion being for the conversion of the pitch and heavier fractions of the tar to a range having lesser densities or lower boiling points, and the upper portion for the further treatment of the vapours. An internal stand pipe was fitted so that any material remaining liquid under reaction conditions could be withdrawn from the bottom. The "light" or "vapour" product, together with the residual hydrogen, left the converter through a side connection near the top, and passed through a water-cooled condenser and thence into a separator. From the top of this separator, the hydrogen and hydrocarbon gases formed during the reaction were continuously released to atmospheric pressure through a needle valve, while the condensed liquid product was drawn off at short intervals by means of a similar valve at the bottom. Dissolved gas released by the drop in pressure from both the "light" and "heavy" product, in addition to the residual gas, was passed through meters to holders for sampling, &c.

The converter was operated for a total of about 1020 hours, the duration of the runs varying from a few hours to seven days. It is apparently still in good condition. Considerable trouble was experienced at times with blockages, particularly in the outlet valve for the heavy product. The blockages were due partly to dust from the catalyst, combined with the pitch-like liquid dealt with. During the intervals between releases, this material was compressed at the valve inlet, and formed a solid mass which would not pass through, in spite of the pressure behind it. Heating the pipes by steam considerably reduced these blockages.

Converter No. 5.—During the course of the experiments on continuous converter No. 4, the need was felt for a small plant in which different catalysts and catalyst supports could be compared with regard to efficiency, rate of deterioration, &c., under some precise set of conditions, more rapidly than was possible in converter No. 4, at the same time leaving the latter free for studying operating conditions and developing the technique necessary for a larger plant. Messrs. Chemical Reactions had developed a suitable plant, and a unit was obtained from them in February, 1932. Details of the converter (No. 5) are given in Fig. 5. Tar and hydrogen enter at the top and pass downward through the catalyst, which is supported by a perforated steel disc. All the products leave through a side connection at the bottom, and pass thence through a condenser, to the high-pressure separator, in a similar manner to the vapour product of No. 4. Heating is effected by an external electric furnace.

The first converter supplied was made of nickel-chrome steel containing 0·13 per cent. carbon, 3·5 per cent. nickel, and 0·8 per cent. chromium. It was not known what life could be expected from this steel, though the available data suggested that it would be considerably longer than mild steel. The converter was visually examined and gauged at intervals without showing any sign of weakness. After 2700 hours under the working conditions of 3000 lb. per square inch and 900 deg. Fah., however, it was deemed wise to remove it from service, and a new converter (No. 5*a*) was installed. The first converter was examined later at the same time as No. 5*a*.

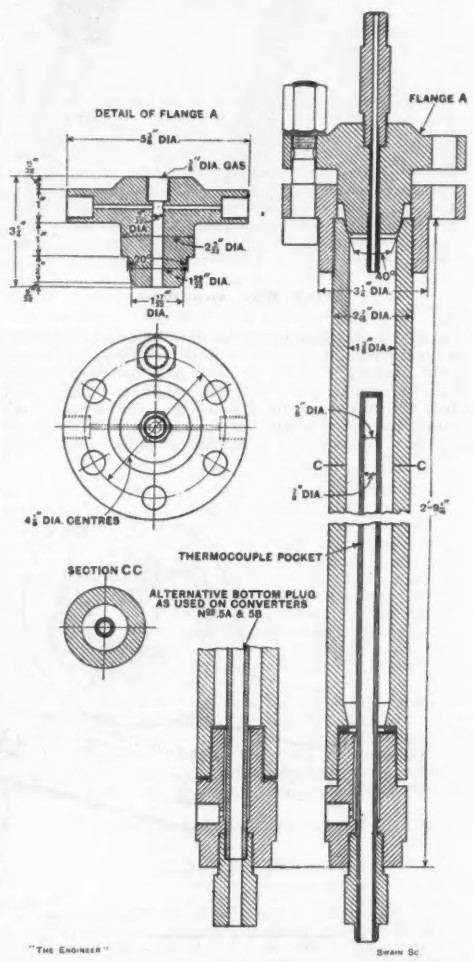


FIG. 5—CONSTRUCTIONAL DETAILS OF CONVERTER NO. 5 FOR TAR

Converter No. 5*a* was made of chrome-molybdenum steel containing 0·3 to 0·4 per cent. carbon, 1·0 to 1·5 per cent. chromium, and 0·25 to 0·35 per cent. molybdenum,

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‡ Scientific Officer II, Fuel Research Station, Greenwich.

and was expected to have a longer life than that of nickel-chrome steel. If no evidence of approaching failure was discerned, it was decided to allow this converter a working life of 5000 hours. This was not actually realised, as at the end of 4520 hours the bottom plug fractured across the lower screw thread. Signs of fracture were first noticed when starting to unscrew the plug after an experiment. It was removed carefully, still whole, and then broke into two pieces quite easily in the hand. It was found to be badly corroded internally. Owing to a covering of deposit, the dangerous thinning of the wall had not been apparent prior to the actual failure. In view of the extent to which corrosion had occurred in the plug the whole converter was taken out of service for examination. A third vessel (No. 5*b*), of the same composition as No. 5*a*, was installed, and this has had a working life, to date, of 6300 hours. No evidence of weakness is discernible.

Corrosion of Pyrometer Pockets.—During the early period when the converters just described were in use, considerable trouble was experienced with thermo-coupled pockets. Those originally supplied were of mild steel. After about 500 working hours each, all were so badly corroded as to be unsafe. The corrosion was quite local, occurring for a distance of about 2in. at a position slightly above the offtake connection for the product in the bottom plug of the converter.

Pieces of 12 per cent. chromium steel tube, such as had been found satisfactory for use in a retort for the low-temperature carbonisation of coal, were tried. The fitting of the first chromium steel tube coincided with a period of increased hydrogen throughput of 40 cubic feet per hour, as against a normal rate of 6 cubic feet per hour (measured at atmospheric pressure), and a five-day run was sufficient to render the tube unserviceable. The corrosion was similar to that of the mild steel tubes, except that there was a narrow unattacked ridge opposite the disc supporting the catalyst. Further tubes of 12 per cent. chromium steel were tried with the lower rate of hydrogen throughput. It appeared, however, that they were very little, if any, better than mild steel.

Blockages sufficient to cause a difference of pressure of 500 lb. to 600 lb. per square inch between the top of the converter and the high-pressure separator have been experienced at times in the offtake connection, but it appeared unlikely that the velocity in the portion adjacent to the thermo-coupled pocket had ever reached a value high enough to cause erosion. The conditions were, of course, favourable for electrolytic action, as the converter body, plug, and tubing, which were of different metals, were in good metallic contact close to the corroded area.

It was decided to try the effect of encasing the next pocket at the position where corrosion was expected. This was done first with a piece of mild steel tube about 3in. long, which was made a sliding fit on the pocket, and later with a piece of "Pyrex" glass. Both were efficacious in protecting the pocket from attack, but the former was itself corroded, as might be expected. The use of a "Pyrex" glass sheath was continued with mild steel pockets for high rates of gas flow until a tube of "V_2A" steel was obtained. This is an austenitic steel, containing approximately 20 per cent. chromium and 7 per cent. nickel and has been very satisfactory in use.

In order to determine, if possible, the method of attack, two pockets of chrome-molybdenum steel, having the same composition as converters Nos. 5*a* and 5*b*, have since been tried in the latter converter. The pocket and nut were in one piece, fabricated from the solid bar, as this material was not available in drawn tube form. Each of these became unsafe after a life of about 150 hours. The attacked area, in these two cases, was smaller and the corrosion took the form of deep pittings which suggested that the attack in this case was of a purely chemical nature rather than erosion or electrolytic action, as the velocity of the vapours close to the joint was certainly low and the metals were all of the same composition. It has been suggested that the erosion is caused by vibration, the damage being in the region of a nodal point. If this is so, evidence of vibration fatigue should be seen in a change in the crystal structure of the metal at this point.

It is gratifying to find that the chrome-molybdenum steel used shows practically no sign of deterioration after 4500 hours' work at a pressure of 3000 lb. per square inch and temperatures in the region of 930 deg. Fah. Unfortunately, no comparison can be made at the moment with the nickel-chrome steel, as the first converter (No. 5) was taken out of service after 2700 hours only. It is hoped to put this into service again. Regarding the thermo-couple pockets, the conclusion reached is that the corrosion is caused by the products of reaction in the region of initial condensation. The product contains sulphur compounds and water vapour. The latter will condense at about 695 deg. Fah. when at a pressure of 3000 lb. per square inch, and the temperature certainly falls below this figure in the bottom plug. The corrosion of the plug and offtake connection are, of course, due to the same effect.

Laboratory Scale Converter No. 10 for Increased Pressure.—A number of experiments have been carried out to determine the effect of pressure on the rate of conversion of tar and tar oil, and the rate of deterioration of the catalyst. The plant just discussed was suitable for a maximum pressure of only 3500 lb. per square inch. For pressures up to 6000 lb. per square inch, another plant, also supplied by Chemical Reactions, was installed. This is on a much smaller scale than converter No. 5, though the general lay-out is the same. The converter, No. 10, is a mild steel block, bored to receive a catalyst tube of "V_2A" steel, $\frac{3}{8}$in. diameter and $8\frac{1}{2}$in. long. It is heated by an external electric furnace. Temperatures are measured by a thermo-couple inserted in a hole drilled in the block, parallel and close to the catalyst tube.

At first, as a suitable compressor was not available, hydrogen at the requisite pressure was obtained by charging one of the alloy steel Bergius converters to a pressure of 3750 lb. per square inch from a compressor, and then increasing it to 6300 lb. per square inch by pumping in water from a hydraulic pump. Additional water was pumped in at two-day intervals until the vessel was three-quarters full of water, when the water was blown out and the vessel recharged with hydrogen. This method was discontinued when a new compressor suitable for a working pressure of 6000 lb. per square inch had been obtained. With this compressor in use, the total hydrogen in the system is little more than 2 cubic feet (measured under atmospheric conditions), as compared with over 500 cubic feet when using the storage vessel, thus reducing the risk in the event of any failure occurring. On one occasion a pressure gauge on the storage vessel, calibrated to 12,000 lb. per square inch, burst at a pressure of 6000 lb. per square inch after a life of only twelve hours, fortunately without any injury to *personnel*.

Internal Heating.—When converter No. 4, the first converter designed at the Fuel Research Station for the continuous hydrogenation of tar, had been in use some months, the advisability of internal heating was considered. External heating, such as obtains when a converter is enveloped in an electrically heated furnace or a lead bath, has several disadvantages, the chief of which is that the pressure retaining walls are at or above the reaction temperature, at which the permissible stress is considerably reduced and liability to attack by hydrogen seriously increased.

The temperature of the pressure retaining vessel may be maintained below that at which either creep or hydrogen attack occurs by using an internal heater and providing thermal insulation between this and the walls and covers. Alternatively, the hydrogen and tar, or coal paste, may be preheated externally to the converter and passed into a central chamber at a temperature sufficient to initiate reaction. Thermal insulation, as before, is placed between the hot zone and the pressure-retaining walls. It should be mentioned that the chemical reaction is exothermic, and consequently the ingredients having been brought to the reaction temperature, it will continue so long as the heat loss does not exceed the exothermic heat.

Converter No. 7.—After some preliminary experiments with an internal electric heater in converter No. 4, a more suitable vessel was acquired, most of the existing auxiliary plant being retained. This converter (No. 7), which is designed for a working pressure of 3000 lb. per square inch at a maximum temperature of 600 deg. Fah., is 6in. in diameter by 3ft. 6in. long internally, and is made of mild steel. The walls are 1in. thick, and the end covers, $2\frac{3}{4}$in. thick, are held in position by six mild steel bolts, $1\frac{1}{4}$in. diameter. Pressure-tight joints are made by means of a copper ring in a serrated groove formed in each end cover, the body having serrated spigots to suit. The catalyst chamber was formed from a piece of 3in. steam tubing. This was surrounded by a slightly larger tube carrying the heater winding, which, for most of the experiments, was in three sections, separately controlled by external resistances. Direct current from the available 220-volt two-wire totally insulated supply was utilised. A water-cooled extension was screwed into one end cover to make sure that the electrical insulating bushes could be maintained sufficiently cool.

Converter No. 7 was run for a total of 1200 hours, when it was succeeded by one of larger capacity, in which more space was allowed for thermal insulation. No. 7 was transferred to coal hydrogenation, where it has worked for another 200 hours and is still in use.

Converter No. 8.—The new converter (No. 8), also of mild steel, is of similar design, but is 8in. in diameter by 4ft. long internally, with walls $1\frac{1}{4}$in. thick and end covers $3\frac{1}{4}$in. thick, held by eight mild steel bolts $1\frac{1}{2}$in. diameter. A catalyst chamber of the same volume as in No. 7 has been employed, together with the same auxiliary plant.

Converter No. 8 has been operated up to the present for a total period of 1350 hours, at a pressure of 3000 lb. per square inch, the longest continuous run being 330 hours. During this time, external wall temperatures have been steadily reduced to below 200 deg. Fah. The electrical terminals are now screwed direct into an end cover.

Before putting either of these vessels (Nos. 7 and 8) into service, the joint spigots were first pulled down hard on the copper ring. The mating surfaces were then ground together until ridges corresponding to the serrations in the spigot face had been formed over the whole circle on the copper ring. This procedure has been found to give a tight joint under the first pressure test without putting excessive tension on to the bolts. The hydraulic test pressure for these vessels was 4800 lb. per square inch. No trouble has been experienced in remaking the joints on the fifty or more occasions when this has been done, and no leak has occurred. The copper rings have not been changed, nor have they received any attention other than being wiped clean since they were fitted.

Electrical Connections.—Considerable trouble was experienced at first with the electrical connections. The three pairs of leads for the three sections—top, centre, and bottom—of the heater, are connected to six electrically insulated terminals, which, of course, have to withstand the working pressure of 3000 lb. per square inch. Coned shoulders on the leads bear on fibre bushes in coned seatings in the terminals. The fibre is thus compressed by the internal gas pressure between the shoulder and the seating. It was comparatively easy to make a tight joint giving good electrical insulation between the various leads and to earth, but on heating, water vapour displaced from the thermal insulating material, &c., condensed on the fibre bushes and around the connections. This condensation soon reduced the electrical insulation to a low figure. It occurred both when the terminals were at the top and at the bottom. Water is also a product of the hydrogenation of tar, and when certain experiments were conducted in which the catalyst chamber was in communication with the heater space for the purpose of pressure equalisation, diffusion of the vapour products was a continuous if small source of moisture. The hydrogen itself is practically dry, water being separated during compression.

The amount of this moisture was sometimes quite remarkable. On one occasion, after drying the parts for several hours before assembly by heating up slowly with a small stream of hydrogen and finally evacuating by means of a vacuum pump, the electrical insulation was still found to be unsatisfactory, and, on dismantling, parts of the interior were found literally drenched with water. Experiments were directed towards preventing the access of water to the fibre and connections, and a heavy oil obtained from the process placed round the terminals has proved effective.

The effect of hydrogen and hydrocarbon vapours on the heaters has also provided interesting problems, but these come outside the scope of the paper. One item may, however, be mentioned. The first tubes on which the heater wire was wound were of fused silica. They were quite substantial, and only required ordinary care in handling. Two broke easily after a short life, and another was found shattered inside the converter after the pressure had been reduced more rapidly than usual. Fracture was due to the hydrogen, which, being forced into the more or less closed pores of the silica, was unable to escape quickly enough when the pressure was reduced. On removal the larger pieces shattered explosively when given a light tap. This phenomenon is known to be possible with glass at higher pressures. For most of the later experiments the heater has been wound on a mild steel tube.

Thermal Insulation.—Problems connected with thermal insulation have also needed investigation. The high efficiency of lagging such as magnesia and asbestos, in common use on steam pipes, &c., is chiefly due to the stagnant air in the spaces between the fibres. The efficiency of these insulating materials is materially reduced when they are employed in a gaseous atmosphere at high pressure, where convection is considerably increased. Great care is necessary in fitting the insulating material in order to reduce convection currents to a minimum; concentric polished metal tubes are fitted to prevent radial diffusion. It has been found that convection effects, if appreciable, can completely cancel the advantage of using a gas of low thermal conductivity instead of hydrogen (which has a high conductivity; about seven times that of air.)

The electrical and thermal aspects will be dealt with more fully in a paper by another member of the staff of the Fuel Research Station in the near future.

Pipes and Connections.

Seizing of Bolts.—When bolts and nuts and other screwed fittings have been subjected for several hours to a temperature of 850 deg. Fah. or more, seizing has on occasions been experienced on removal, necessitating the destruction of the fitting before dismantling could be effected. This trouble has occurred with mild steel bolts and nuts, and with various alloy steel bolts with nuts of similar material or of mild steel.

The usual procedure is to rub dry flake graphite well into the surfaces, or to paint them with a paste of graphite and water. Oil is unsuitable, as it carbonises and encourages seizure. This practice has generally proved very efficient. Such trouble as has occurred in spite of this precaution is possibly attributable to uneven tightening of the several bolts round the joint, to incorrectly formed threads, or to the stretching of the bolts while being subjected to heat.

Blistering of Drawn Tubing.—The pressure-resisting pockets for housing the thermo-couples in converters Nos. 7 and 8 have usually been formed of mild steel hydraulic tubing. Owing to frequent changes in the design of the internal parts, these pockets are not required to have a long life; mild steel has therefore been used. The usual practice is to close one end by means of smith welding and to screw the other (after "jumping" it, if necessary, to a suitable size of gas thread), into the cover or plug. The joint is of the type shown at *d* in Fig. 6, but without the hexagon nut, and is entirely satisfactory in use. The pressure, it will be noted, is here forcing the seatings together.

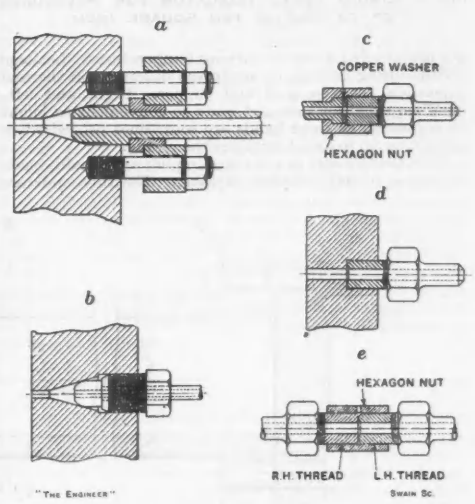


FIG. 6—TYPES OF HIGH-PRESSURE JOINTS

These pockets have also produced some interesting experiences. On two occasions when the temperature rose to the region of 1300 deg. Fah., due to violent local exothermic reaction, the pockets were flattened by the pressure. This, of course, put the thermo-couples out of action, but no leakage occurred. On another occasion the nickel thermo-couple tube was found to be gripped tightly in the pocket. After dismantling, no external distortion of the pocket was apparent, but a blister had been formed by the hydrogen on the inner surface of the tube. On occasions when the outlet pipe had become blocked, it was heated with a blow-lamp to clear the obstruction, and on subsequently cutting out the pipe, the blister was found. Blisters have also occurred in the 3in. steam tubes used for the reaction chamber of converter No. 8. These doubtless originate with small internal flaws in the wall of the tube originally formed during the drawing process, which become filled with hydrogen by pressure absorption. When the metal is heated to a softening temperature a blister is formed by expansion of the entrapped gas. Local corrosion has also occurred in the thermo-couple pockets of converter No. 8 similar to that in No. 5, and due apparently to the same cause.

Types of Joints.—Several types of connections between two lengths of high-pressure pipe or between a pipe and a high-pressure vessel are in common use. These are shown in Fig. 6. Provided that such fittings are of good workmanship and that reasonable care is taken in making

the joints, very little trouble is experienced with gas pressures up to 6000 lb. per square inch. The use of a copper washer is satisfactory when the joint has to be broken and remade frequently, and where the surfaces are liable to maltreatment during cleaning and dismantling. The loose copper washers used for pipe joints are annealed or renewed after every three or four occasions, as they become work-hardened in use and cannot be replaced in the exact relative position each time. Copper washers

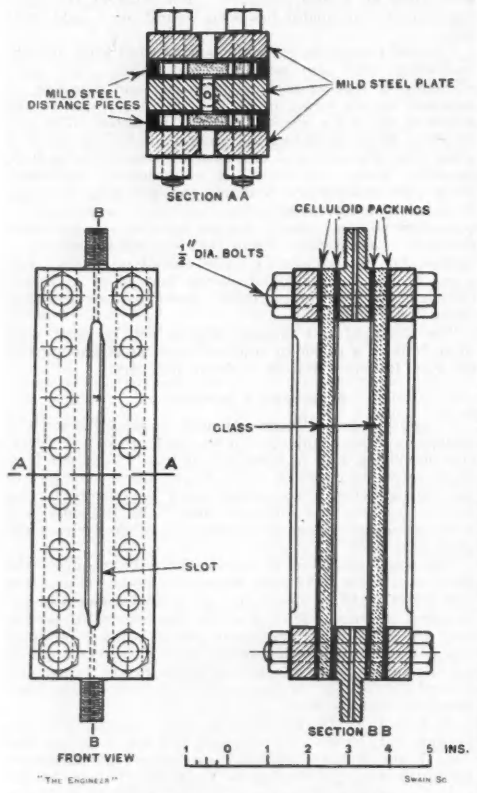


FIG. 7—LIQUID LEVEL INDICATOR FOR PRESSURES UP TO 3000 LB. PER SQUARE INCH

are unsuitable for use at varying temperatures. Leakage occurs during cooling, owing to the difference in thermal expansion between steel and copper. Right and left-hand threaded nuts are not quite so convenient as might be supposed, as three hands are sometimes needed when tightening up to avoid straining the piping.

Permanent joints in mild steel piping are usually made by means of oxy-acetylene welding. The tube ends are chamfered to an angle of 45 deg., and, where possible, are held in line by inserting a piece of rod while they are being "tacked." For a period when the welding operator was first called upon to make welds to withstand hydrogen at high pressure, faulty joints often occurred, due to slag inclusions and porosity of deposited metal. This was particularly the case if the tubing could not be completely rotated as the weld was made. It was found, too, that after tubing or other steel parts had been in contact with hydrogen under pressure for a comparatively short time, it was difficult to make a weld, owing to absorption of hydrogen in the metal. The hydrogen can be driven out by heating the steel for a short time to 250 deg. to 350 deg. Fah., after which a satisfactory weld can often be made, but it is safer to renew the two lengths of tubing. Trouble with welded joints is now extremely rare. No failures have been attributable to chemical attack at a welded joint.

High-pressure Liquid Level Indicators.

Knowledge of the level of liquid in a vessel is often required. Several types of level indicators can be made suitable for high pressures, such as :—

(1) The magnetic float type, where the position of a float on the surface of the liquid in the pressure vessel is indicated externally by magnetic means.

(2) The electrical resistance method, in which the level of the liquid can be calculated from the variation in the resistance of a wire placed inside the pressure vessel.

(3) The direct-vision type, similar to a boiler water-level gauge.

Provided that (3) can be made safe this type has obvious advantages. Accordingly, after a little experimenting, the gauge shown in Fig. 7 was constructed in February, 1933, for use on the separator for the gas and liquid products of plant No. 8. It is of the double-plate type, the glass being Pilkington's "Armourplate." Celluloid is used as packing, the outer sheets completely covering the glass.

The method of fracture of this glass when subjected to excessive stress is to split into minute pieces. After fracture, however, the glass retains its original external form and may be picked up as a whole. The object of the celluloid cover is to prevent the fragments being separated and blown out by the escaping gas in the event of failure. It would appear to have had the desired effect, as when glass ¼in. thick was employed a failure actually occurred while the gauge was in use at a pressure of 3000 lb. per square inch. The gas and liquid escaped at the top and the operator was able to shut the two valves between the gauge and the pressure vessel without difficulty. Although the front glass was completely shattered, every piece remained in position. Glass having a thickness of ⅜in. has since been used, and the gauge has been operated at the above-mentioned pressure for 2600 hours without any trouble.

It is essential that the surfaces of the steel and the glass should be flat. The packing, whether hard or soft, cannot make up for inequalities greater than 0·003in. between the surfaces. Several firms have developed liquid level gauges along somewhat similar lines.

Large-scale Tar Plant.—The work on the several small-scale tar hydrogenation plants recently reached the stage at which a large unit could be designed and a converter (No. 12) has since been obtained. The nominal throughput is 300 gallons of tar per day, the amount depending partly on the pressure employed, which will be from 3000 lb. to 6000 lb. per square inch.

The converter, shown in Fig. 8, is suitable for the maximum pressure mentioned. The joints are similar to those on converter No. 8, except that both the face of the spigot and the groove are turned to a wave form in section. The lower flange of the converter is extended beyond the end cover so that the cylinder can be supported in a vertical position, while allowing easy removal of the bottom end cover. Four flats are formed on the extended cylinder flange to prevent rotation when the joints are being made.

Experience with converter No. 8, already mentioned, has shown that the temperature of the steel forming the pressure-resisting walls need not exceed 200 deg. Fah. The possibility of a temperature of 500 deg. Fah. was allowed for; this figure is, however, below that at which creep need be considered. and a heat-resisting steel is not necessary. There was general agreement that a nickel-chrome-molybdenum steel was the most suitable, and it was decided to accept a vessel in this steel made by the English Steel Corporation, of Sheffield. The cylinder and end covers are of this steel, in the hardened and tempered condition, containing 0·27 per cent. carbon, 2·41 per cent. nickel, 0·72 per cent. chromium, and 0·35 per cent. molybdenum, and having a yield stress of about 38 tons per square inch, a maximum stress of 50 tons per square inch, and an elongation of 22 per cent. on 2in., with a contraction of about 55 per cent. The bolts are of "Vibrac V.30" steel, which is also a nickel-chrome-molybdenum steel, while the nuts are of mild steel.

The completed cylinder was subjected to a hydraulic test pressure of 7700 lb. per square inch, when the extensions given in the table below were observed.

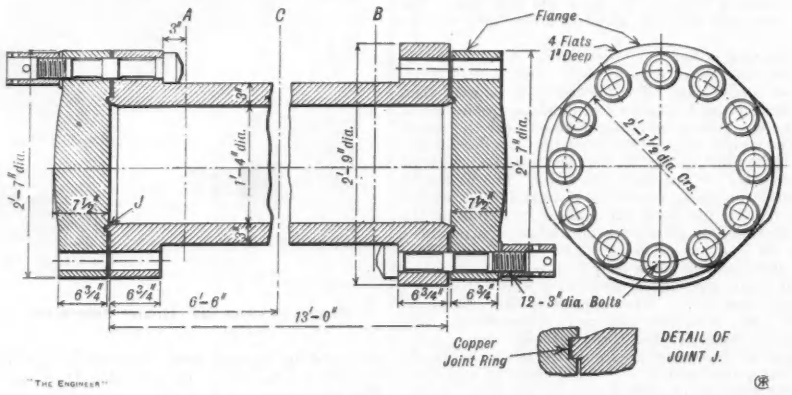


FIG. 8—CONVERTER NO. 12 FOR TAR

Pressure, lb. per sq. in.	Diameters (inches) at			Increase in length, inches.	Length of bolts, inches.		Width of flange gaps, inches.	
	A*	B	C	D	E	F	G	H
0	22·0025	22·0025	22·001	0·000	20·500	20·500	0·152	0·163
7700	22·105	22·105	22·010	0·023	20·511	20·513	0·161	0·175
Difference	0·0125	0·0125	0·009	0·023	0·011	0·013	0·009	0·012

* The reference letters refer to dimensions in Fig. 8.

The maximum calculated hoop tension in the walls, when subjected to an internal pressure of 6000 lb. per square inch with no temperature gradient, is 8·7 tons per square inch, and the equivalent simple stress from the shear hypothesis is 11·38 tons per square inch. In the case of a converter not heated *vid* the pressure-resisting walls, the heat flow is outwards, giving a higher temperature at the inner surface than at the outer. This causes an increase of hoop tension at the outer surface and a decrease at the inner surface, and the safety factor is thereby increased.

The difference between the elongation of the bolts and the flange gaps is due to deflection of the cover and flange.

It has not been possible for the authors, in the short space of this paper, to include any of their experiences with hydrogen compressors, tar, and paste pumps, and other subsidiary plant, but it is hoped to publish some account of these later.

CATALOGUES.

Broom and Wade, Ltd., High Wycombe.—A new catalogue of pneumatic tools and accessories.

B.E.N. Patents, Ltd., Gorst-road, Park Royal, N.W.10.—Air compressor catalogue No. C.B. 35.

Edgar Allen and Co., Ltd., Sheffield, 9.—A pamphlet on files and a loose-leaf folder on steel castings.

Grace Engineering Company, Ltd., 148, Leadenhall-street, E.C.3.—Catalogue S.10 of Smoot regulators.

Ransomes and Rapier, Ltd., Ipswich.—Publication 353 of gang trolleys and inspectors' cars for railways.

British Aluminium Company, Ltd., Adelaide House, King William-street, E.C.4. —"Aluminium in Shipbuilding."

Robert Boby, Ltd., Bury St. Edmunds.—Folder M.B.D. 313, illustrating grain and malt cleaning and handling plant.

Adam Hilger, Ltd., 98, King's-road, N.W.1.—"Optical Gauging and Inspection in Modern Engineering Practice."

Brookhirst Switchgear, Ltd., Chester.—Leaflets on machine tool switches and a booklet on electric control of machine tools.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

Stelp and Leighton, Ltd., 9–13, Fenchurch-buildings, Fenchurch-street, London, E.C.3, are acting as general agents in Great Britain and Ireland for the Maier form bow.

Huntington, Heberlin and Co., Ltd., 47–51, King William-street, London, E.C.4, are removing from King William-street to Suite C.B. 706/717, Bush House, Aldwych, London, W.C.2, on December 8th next.

Mr. A. W. Swan informs us that he has been appointed manager of the publicity and sales promotion department of the United Steel Companies, Ltd., Sheffield, from December 1st, in succession to Mr. F. Rowlinson, who is leaving to join Rowlinson-Broughton, advertising agents, in Manchester.

Institution of Naval Architects.—The following scholarships, which are tenable for three or four years, according to the length of the course at the University selected, will be offered for competition in 1935 :—Naval architecture : Martell, £130 per annum ; Trewent, £125 per annum. Marine engineering : Yarrow, £100 per annum ; Denny (for boys from public or secondary schools ; for this scholarship the examination subjects are non-technical), £75 per annum for four years at Glasgow University. Age limit for the "Denny" Scholarship, under nineteen years ; for the other scholarships, under twenty-three years. Full particulars may be obtained from the Secretary of the Institution of Naval Architects, 2, Adam-street, Adelphi, London, W.C.2.

Engineers' German Circle.—The annual dinner and dance of the Engineers' German Circle took place on Monday, November 19th, at the Holborn Restaurant. In spite of the foggy weather then prevailing, there was a good attendance of the members and friends of the Circle and their ladies, and a very pleasant evening was spent. Dr. S. J. Davies presided at the dinner and welcomed the guests. Greetings were sent to Dr. Conrad Matchoss and the German Circle of English-Speaking Engineers in Berlin. Inquiries with regard to the membership and activities of the London and Berlin Circles should be addressed to Mr. H. P. Spratt at the Science Museum, London, S.W.7. The next meeting of the Circle will take place at the Institution of Mechanical Engineers on Monday, December 3rd, at 5.15 for 6 p.m., when a lecture will be delivered by one of the engineers of Siemens-Schuckert on "Automatic Welding Machines."

Electrical Propaganda Films.—At the invitation of the British Electrical Development Association we attended the premiere of the Association's propaganda films at the Prince Edward Theatre on Wednesday, November 21st. The films are intended to afford supply authorities an opportunity of supplementing the more usual forms of propaganda and will be shown at clubs, institutes, and electricity showrooms, &c. Contracts are said to have already been signed for practically 3000 performances to be given in some thirty or forty towns during the present season, and one municipal authority in the provinces alone has ordered 250 displays. The scenarios have been prepared with the co-operation of the Western Electric Company, which is to undertake the distribution and showing of the films to audiences interested in improving domestic and civic conditions. Although the films have no direct connection with heavy electrical engineering, if they lead to a more widespread use of electricity they will, naturally, benefit the manufacturers of plant, as well as those who concentrate on the production of heaters, cookers, and other current-consuming appliances. They were produced by London Films Productions, Ltd., under the supervision of Mr. Alexander Korda, with Mr. Alexander Esway acting as director. The three films are entitled "The Wizard in the Wall," "Well, I Never," and "Plenty of Time to Play." In the first, children who ask for a bedtime story are told of the discoveries of Thales, Gilbert, Franklin, Humphrey Davey, Faraday, and Swan, the birth of the electrical industry and the evolution of the grid. The second, which is likely to lead the gas people to produce a film that will demonstrate how a meal may be ruined by a failure of the grid, shows a kitchen in which everything is going wrong and in which all difficulties were ultimately surmounted by the introduction of electricity. The third, "Plenty of Time for Play," portrays the future by showing, among other things, how a letter dated August 1st, 1955, will be dictated into a combined dictaphone and typewriter and how ease and cheerfulness of life will be secured when all the services that electricity can render are developed to the full.

Markets, Notes and News.

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer. A comprehensive list of the prices of materials mentioned below will be found on the next page.

The International Steel Trade.

The Continental steel makers do not attempt to disguise their disappointment at the turn events have taken in the export markets. Anticipations of heavy buying by users in South American countries, the Far East, India, and some of the British Colonies, which have hitherto taken fair quantities of Continental steel, have failed to materialise. The demand was satisfactory during the latter part of September and early in October, but has gradually tapered off since. In Germany the home trade requirements provide a considerable proportion of the business reaching the steel works, and the barter arrangements which the German Government is fostering have brought a considerable volume of export trade. In fact, the steel manufacturers of France and Belgium complain that in a number of markets the Germans, by their barter transactions, have left little business to be obtained by ordinary trading. This has created ill feeling amongst the members of the European Steel Cartel, the more so as the Germans claim that these transactions should not be included in the quota allotted to Germany by that organisation. The argument they use is that had they not taken this business by barter, it would have been placed with other countries outside the Cartel. At the moment an interesting transaction of this description is being negotiated by which 100,000 tons of German angles, plates and light rails may be exchanged for 20,000 tons of American copper. It is by no means certain, however, that this deal will go through, as it is likely to meet with official opposition in the United States. The competition from Polish works which are not in the Cartel is also causing some concern, and recently they are reported to have taken orders of about 40,000 to 50,000 tons of steel from Russia, as well as a big order for ship plates from Japan. The French home market is less active than it was earlier in the year, so that the scarcity of export business is keenly felt by the French steel works. In Belgium also the position is not satisfactory, and in spite of a steady stream of business in steel bars which reached the Belgian works during October and the first part of November, the mills are not carrying a sufficient reserve of orders. Complaints by the Continental steel works of British competition in overseas markets is a fresh development in the world steel position, and is an encouraging sign of the recovery of the British steel industry.

The Pig Iron Market.

Although the position varies in different parts of the country, the demand for pig iron on the whole is satisfactory. There was a lull in business in this department during the earlier part of the month, but for the past two weeks there has been a large volume of buying and a fair proportion of it consisted of forward contracts. The producers in practically all districts will now enter the New Year confident that they will be able to maintain the present rate of output over the greater part of the first quarter. On the North-East Coast production shows no signs of slackening; the full output is being taken up by consumers and inroads are being made into the moderate stocks in the makers' yards. During the past week there was some substantial buying, and the local, as well as the Scottish foundries, placed orders for delivery over the second quarter of 1935. Some contracts also fall due for renewal next month, and it is not expected that buyers will hold back while the market is in its present condition. Although there is talk of more furnaces being put into blast, the makers give no indication of fulfilling these expectations for the time being. The feature of the Midland pig iron market is the recovery which has been made from the slack conditions ruling earlier in the month. In some cases consumers then failed to keep up to date with their specifications, but these arrears look like being overtaken by the end of the year. Recently some contracts were entered into for supplies covering March and April of next year; but most of the buying of Midland iron has been limited to small lots. The heavy engineering firms are busier, and lately they have been taking more pig iron and there has been also a rather better demand for special sorts from this industry. The Scottish ironmasters are experiencing a steady request, but business does not show much sign of increasing. Considerable quantities of Cleveland iron are reaching the light castings foundries, and imports of Indian iron are sufficient to give rise to complaints on the part of the local producers. In the Lancashire market the demand is steady, but buying has been on a moderate scale as most of the large users have covered their requirements for the time being. Business in hematite has been fairly active, and users are taking heavy deliveries, particularly those in the Sheffield district. The export trade in this iron has fallen off somewhat since the price was advanced from 61s. f.o.b. to 62s. 6d. Although comparatively little basic iron comes on the open market, the production is well maintained, as is disclosed by the October figure of 267,200 tons, compared with 245,700 tons in September.

The Midlands and South Wales.

One or two branches of the steel market in the Midlands have developed a rather quieter tone; but, in view of the long-sustained demand for most descriptions of steel, this is not surprising. There is no falling off in the requirements of the structural engineers, most of whom have contracts in hand which will keep them well employed until February or March. As a result the manufacturers of joists and sections have a good tonnage of orders in hand; but deliveries are somewhat irregular, as most constructional engineers only take their supplies as they require them. Buying by the motor car industry seems to have set in in earnest, particularly for strip and special steels. Some producers of the latter are not so well situated as they were a year ago, but the demand at that time was almost unprecedented. There has been no change in the price of strip, which stands at £9 7s., but makers outside the Association have taken a good proportion of the business at figures ranging from £8 10s. to £8 15s. Latterly there has not been so much Continental strip offered, the quotations varying from £7 10s. to £8 10s. The Midland re-rollers are irregularly employed, but on the whole the volume of business reaching the works is not unsatisfactory. In this branch there has been no relaxation in the keen competition between the associated and non-associated makers of small bars. The unassociated works quote £7 10s. to £7 15s. Lately more interest has been shown in Continental steel and a number of good-sized orders have gone to the foreign works at prices which come out at about £7 1s. for small bars, delivered and including duty. Business in black sheets has expanded and some of the works have taken enough orders recently to ensure fairly good working until the end of January. The plate mills, however, have been poorly off for work, but recently there has been some substantial buying. The South Wales steelworks are actively employed and in some cases difficulty is experienced in keeping up with consumers' requirements. The works producing sheet and tin-plate bars are particularly busy.

North-East Coast and Yorkshire.

The producers of finished steel materials on the North-East Coast have done much better during the past week or two than for some time past. The contracts for new ships placed on the Tyne have created a better tone in the district, and some fair-sized orders for rails have reached the makers just when they were getting short of work. Fresh business of this description, however, would be welcome, as a number of contracts have been worked off or will shortly be completed. The structural engineering shops are well employed, and there is a good request for joists and sections. Recently a contract for structural steel valued at over £100,000 was placed with works on this coast, and this, with the steady flow of smaller orders which has developed, has improved the steel makers' chances of entering 1935 with comfortably filled order books. The demand for plates has shown welcome signs of improving, and some of the mills now have several weeks' work in front of them. The sheet makers, who have experienced a scanty demand for several months, have improved their position, partly as a result of increased business with home consumers, but also owing to an expansion in export trade. Few transactions have been reported in boiler plates since the sharp burst of activity that preceded the establishment of a fixed price. This movement, however, has caused few complaints, since rather chaotic price conditions had ruled previously. The new quotation of £9 5s. is not considered extravagant, although some buyers resent the conditions necessary to obtain the rebate of 15s. In the Yorkshire district the steel makers are facing the future in a spirit of confidence that appears to be growing stronger as the year approaches its end. The output of acid and basic steels is maintained and the producers have good order books. The works producing high-speed steels are in a good position, and specifications are reaching them at a good rate; but new business has shown symptoms of declining lately. On the other hand, the demand for stainless steel is as vigorous as ever, and has been increased during this quarter by some substantial orders arising from its use in the manufacture of road studs. The special steel section of the market has developed some irregular features, but this is regarded as merely a passing phase. The Yorkshire re-rolling industry is working at a fair rate of capacity, but some of the mills would like to see a greater reserve of orders on their books. Thos. W. Ward, Ltd., of Sheffield, have acquired for dismantling purposes the Bennerley blast-furnaces near Ilkeston. The furnaces were built by Mr. E. P. Davis about 1870. The plant produced the well-known "Awsworth" brand of Derbyshire foundry pig iron. For twenty years only two of the three original furnaces have been in blast, and the furnaces have not produced pig iron since March, 1931. The Erewash blast-furnaces of the same company were dismantled five years ago by Thos. W. Ward, Ltd.

Current Business.

The Birmingham Carriage and Wagon Company has received an order from the Entre Rios Railway Company for eleven Diesel railcars of 260 h.p. Japanese shipbreakers have bought the White Star liner "Adriatic" for £65,000. It is reported that the Union Castle Line has placed a contract for two motor ships with Harland and Wolff, of 13,000 tons each, and that the Blue Star Line has placed orders for three motor vessels of 11,000 tons each for its New Zealand trade. A new company to take over the ship and engine repairing and constructional steel work of Palmer's Shipbuilding and Iron Company, Ltd., of Hebburn-on-Tyne, has been registered as Palmer's Hebburn Company, Ltd. A contract for ore handling plant for the British (Guest, Keen, Baldwins) Iron and Steel Company, Ltd., of Cardiff, valued at £100,000, has been awarded to Head, Wrightson and Co., Ltd., of Teesdale Ironworks, Thornaby-on-Tees. The plant will include a travelling grabbing crane, gantries, wagon hoists, wagon drops, transfer cars, bunkers, and two Wrightson Ruingquist patented distributors. The Department of Overseas Trade reports that the following contracts are open for tender:—South Africa, Electricity Supply Commission (Durban): steam-raising plant, steam turbine-driven alternators, three feed pumps, steam or electrical, feed heaters and surge tanks (Johannesburg, January 29th); Railways and Harbours Administration: twelve electric capstans for Port Elizabeth, about 170 tons of steel work for bridges, wrought iron short straight link chains (Johannesburg, January 7th); Argentine State Railways: two Sulzer No. 32–12½ D–11, or similar, centrifugal pumps with suction and delivery piping 125 mm. in diameter, output of 150 cubic metres per hour at a manometric head of 28 m., coupled to a 24 h.p. motor for supply at 440 volts D.C.; one Sulzer No. 18½ e.D., or similar, centrifugal pump, suction and delivery piping 100 mm. in diameter, output 57 cubic metres per hour at manometric head of 45 m., coupled to a 23 h.p. motor for supply at 440 volts D.C.; one voltmeter, D.C., with scale of 1–500 volts, for fixing on switchboard; one ammeter, D.C., 1–50 ampères (Buenos Aires, December 20th); Argentine Department of Navigation and Ports: 1800 metric tons of "Vignole" type steel rails, 37 kilos. per metre in lengths of 10 m.; 5400 pairs of fish-plates; 10,000 kilos. of bolts for fish-plates; 70,000 kilos. of dog spikes (Buenos Aires, December 12th); State Oilfields Directorate: 154,110 m. of weldless steel tubes, mainly black gas threaded, of various sizes (Buenos Aires, December 18th). Lithuania, Klaipeda Harbour Board: Three electrically-operated semi-portal cranes (Klaipeda, Memel, December 27th); Siam, Royal State Railways: 197,000 mild steel rivets and 26,500 split pins (Bangkok, December 24th). A Canadian firm is inquiring for quotations for half-oval high carbon bright finished wire for the manufacture of hairpins. Siam, Royal State Railways: 10,000 kgs. of flat spring steel ribbed and grooved (Bangkok, January 25th).

Ferro-alloys.

The most interesting development in the ferro-alloy market this week has been the announcement that the Import Duties Advisory Committee has added to the Free List as from November 23rd "silicon and alloys thereof containing not less than 95 per cent. of silicon." It is pointed out in a memorandum that commercial silicon is used in the manufacture of various alloys of aluminium, copper and bronze, while alloys containing a very high percentage of silicon are used in the manufacture of certain steels. Both classes of material are made in the electric furnace and production is confined to countries where hydro-electric power is cheap. There seems to be little likelihood of production on a commercial scale in this country in the near future. The Committee states that the duty payable upon the imported material represents an appreciable item in the cost of production of the special alloys made therefrom, and that its removal is desirable in order that the British manufacturers may be at no disadvantage with their foreign competitors, particularly in the export markets. Lately, business in ferro-silicon has been quiet and prices have been unaltered. In other departments of the ferro-alloy market the position has not materially changed during the past few weeks. The demand for ferro-chrome also has been on the light side, but this applies more particularly to the higher carbon grades and a steady business has passed in the lower carbon material. Prices are steady at £29 15s. for 2–4 per cent. carbon (10s. per unit), and £21 12s. 6d. for 6–8 per cent. carbon (7s. per unit). The tungsten market seems to have entered upon a period of dull trading and new business is scarce. One reason for this is probably that the impression prevails that prices will recede in the New Year. There has been an active business in ferro-molybdenum and the demand seems likely to expand. There has been a fair demand for ferro-titanium, but transactions in ferro-manganese have shown a tendency to decrease in number and volume.

Copper and Tin.

No definite news has been received regarding the progress of the negotiations between the copper producers regarding a scheme for controlling output, and this naturally leaves the market very much at the mercy of contradictory rumours. Consumers in all parts of the world are not carrying large stocks, but at the same time they are showing little inclination to increase their purchases, even under the threat of reduced production. This has probably influenced producers, and the view of the market seems to be gradually turning round to the belief that some plan will be adopted at the formal meeting which, it is understood, will take place in Europe during December. The American producers' proposal that they should reduce production by 33⅓ per cent. whilst those in other countries make a cut of 25 per cent., is not regarded with much favour, as it is considered that this is going to the extreme, and that it would be better for the producers to adopt an arrangement for a moderate curtailment over a few years. It is understood, however, that the Americans wish to make so drastic a cut that there will be a good prospect of raising the world price to the official quotation of 9 c. now ruling in the United States. It is hardly surprising, however, in the conditions which have existed lately that prices have been on the easy side, the quotation now being 6·95 c., or £31 2s. 6d. c.i.f. Heavy sales have taken place in the standard market which have been attributed to African producers, and it is estimated that something like 10,000 tons have been taken up by speculators and dealers. . . . The meeting of the International Tin Committee in Paris last week did not produce any particularly interesting development. It was decided to leave the tin quota for the first quarter of 1935 unchanged at 40 per cent. of the standard tonnage, and to allow the additional quota of 4 per cent. which was agreed to in January for the purpose of wiping out surplus stocks to expire at the end of the year. In some quarters it was anticipated that a reduction in the quota would be made, but possibly the decision of the Committee was influenced by the more favourable statistics issued by the International Tin Research and Development Committee. These showed that up to the end of September this year 134,500 tons had been used in manufacture, an increase of 6·9 per cent. over the previous year. Business with America has improved, but the Continental demand, which showed signs of increasing, has again declined.

Current Prices for Metals and Fuels.

Makers' official home trade prices, per ton, delivered buyers' stations. Sections, joists and plates are subject to a rebate to home users purchasing only from associated British Steelmakers: joists, 22s. 6d.: plates and sections, 15s. Export orders of 250 tons and over may be subject to special quotations.

PIG IRON.

	Home. (*D/d Teesside Area*) £ s. d.	Export. £ s. d.
N.E. Coast—		
Hematite Mixed Nos.	3 8 6	3 0 0
No. 1	3 9 0	3 1 0
Cleveland—	(*D/d Teesside Area*)	
No. 1	3 10 0	3 4 0
No. 3 G.M.B.	3 7 6	3 1 6
No. 4 Forge	3 6 6	3 0 6
Basic (*Less 5/– rebate*)	3 7 6	—
Midlands—		
Staffs.—	(*Delivered to Black Country Station*)	
North Staffs. Foundry	3 11 0	—
„ „ Forge	3 6 6	—
Basic (*Less 5/– rebate*)	3 12 6	—
Northampton—		
Foundry No. 3	3 7 6	—
Forge	3 2 6	—
Derbyshire—		
No. 3 Foundry	3 11 0	—
Forge	3 6 0	—
Scotland—		
Hematite, f.o.t. furnaces	3 11 0	—
No. 1 Foundry, ditto	3 12 6	—
No. 3 Foundry, ditto	3 10 0	—
Basic, d/d (*Less 5/– rebate*)	3 7 6	—
N.W. Coast—		
Hematite Mixed Nos.	3 12 6 d/d Glasgow; 4 0 6 „ Sheffield; 4 5 6 „ Birmingham	

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
Lancs.—		
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
S. Yorks.—		
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
Midlands—		
Crown Bars	9 15 0	—
Marked Bars (Staffs.)	12 0 0	—
Nut and Bolt Bars	7 5 0 to 7 15 0	—
Scotland—		
Crown Bars	9 12 6	9 5 0
Best	10 2 6	9 15 0
N.E. Coast—		
Common Bars	9 12 6	8 15 0
Best Bars	10 2 6	9 15 0
Double Best Bars	10 12 6	10 0 0

STEEL.

	Home. £ s. d.	Export. £ s. d.
London and the South—		
Angles	8 10 0	7 7 6
Tees	9 10 0	8 7 6
Joists	8 17 6	7 7 6
Channels	8 15 0	7 12 6
Rounds, 3in. and up	9 10 0	8 7 6
„ under 3in.	8 14 6	—
Flats, 5in. and under	8 14 6	7 2 6
Plates, ¼in. (basis)	9 0 0	7 15 0
„ 5/16in.	9 5 0	8 0 0
„ ⅜in.	9 10 0	8 5 0
„ 7/16in.	9 15 0	8 10 0
„ ½in.	9 10 0	8 5 0
North-East Coast—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Plates, ¼in.	8 15 0	7 15 0
„ 5/16in.	9 0 0	8 0 0
„ ⅜in.	9 5 0	8 5 0
„ 7/16in.	9 10 0	8 10 0
„ ½in.	9 5 0	8 5 0
Boiler Plates, ¼in.	9 5 0	8 5 0
Midlands, and Leeds and District—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¼in. (basis)	8 17 6	7 15 0
„ 5/16in.	9 2 6	8 0 0
„ ⅜in.	9 7 6	8 5 0
„ 7/16in.	9 12 6	8 10 0
„ ½in.	9 5 0	8 5 0
Boiler Plates, ¼in.	9 7 6	7 15 0 to 8 5 0

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
Glasgow and District—		
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¼in. (basis)	8 15 0	7 15 0
„ 5/16in.	9 0 0	8 0 0
„ ⅜in.	9 5 0	8 5 0
„ 7/16in.	9 10 0	8 10 0
„ ½in.	9 5 0	8 5 0
Boiler Plates	9 5 0	8 5 0
South Wales Area—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 0
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¼in. (basis)	8 17 6	7 15 0
„ 5/16in.	9 2 6	8 0 0
„ ⅜in.	9 7 6	8 5 0
„ 7/16in.	9 12 6	8 10 0
„ ½in.	9 10 0	8 5 0

Ireland—	Belfast. £ s. d.	Rest of Ireland. £ s. d.
Angles	8 12 6	8 15 0
Tees	9 12 6	9 15 0
Joists	9 0 0	9 2 6
Channels	8 17 6	9 0 0
Rounds, 3in. and up	9 12 6	9 15 0
„ under 3in.	9 2 0	9 4 6
Plates, ¼in. (basis)	9 0 0	9 2 6
„ 5/16in.	9 5 0	9 7 6
„ ⅜in.	9 10 0	9 12 6
„ 7/16in.	9 15 0	9 17 6
„ ½in.	9 12 6	9 15 0

OTHER STEEL MATERIALS.

Sheets.	Home. £ s. d.	Export. £ s. d.
10-G. to 13-G., f.o.r.	9 0 0	8 15 0
14-G. to 20-G., d/d	10 5 0	9 0 0
21-G. to 24-G., d/d	10 10 0	9 5 0
25-G. to 27-G., d/d	11 2 6	9 17 6

The above home trade prices are for 4-ton lots and over; 2-ton to 4-ton lots, 10s. per ton extra; and under 2-ton lots, 30s. per ton extra.

Galvanised Corrugated Sheets, Basis 24-G.

Home.	£ s. d.
4-ton lots and up	13 0 0
2-ton to 4-ton lots	13 7 6
Under 2 tons	15 0 0

Export: £16 12s. 6d., c.i.f. duty paid India.
„ £11 5s. 0d., f.o.b. other markets.
„ Scandinavian Markets free.

Tin-plates.
20 by 14 basis, f.o.b. Bristol Channel ports, 18/2.
Tin-plate Bars, d/d South Wales Works, £5 7s. 6d.

Billets.	£ s. d.
Basic (0·33% to 0·41% C.)	6 12 6
„ Medium (0·42% to 0·60% C.)	7 2 6
„ Hard (0·61% to 0·85% C.)	7 12 6
„ „ (0·86% to 0·99% C.)	8 2 6
„ „ (1% C. and up)	8 12 6
Soft (up to 0·25% C.), 500 tons and up	5 10 0
100 tons	5 15 0
Rails, Heavy, 500-ton lots, f.o.t.	8 10 0
„ Light, f.o.t.	7 10 0

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	3/3 per lb.	
Ferro Tungsten	3/– per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£23 0 0	7/–
„ „ 6 p.c. to 8 p.c.	£21 12 6	7/–
„ „ 8 p.c. to 10 p.c.	£21 12 6	7/–
„ „ Specially Refined		
„ „ Max. 2 p.c. carbon	£34 0 0	11/–
„ „ „ 1 p.c. carbon	£38 15 0	12/–
„ „ „ 0·70 p.c. carbon	£42 0 0	12/6
„ „ „ carbon free	10d. per lb.	
Metallic Chromium	2/5 per lb.	
Ferro Manganese (loose)	£10 5 0 home	
„ Silicon, 45 p.c. to 50 p.c.	£13 0 0 scale	5/– p.u.
„ „ 75 p.c.	£18 7 6 scale	6/– p.u.
„ Vanadium	12/8 per lb.	
„ Molybdenum	5/6 per lb.	
„ Titanium (carbon free)	9d. per lb.	
Nickel (per ton)	£200 to £205	
Ferro Cobalt	5/3d. per lb.	

NON-FERROUS METALS.

Official Prices, November 28th.

Copper—		
Cash	£27 10 0 to £27 11 3	
Three months	£27 16 3 to £27 17 6	
Electrolytic	£30 10 0 to £31 0 0	
Best Selected Ingots, d/d Birmingham	£31 0 0	
Sheets, Hot Rolled	£58 0 0	
	Home.	Export.
Tubes, Solid Drawn (basis)	9½d.	9½d.
„ Brazed (basis)	9½d.	9½d.
Brass—		
Ingots, 70/30, d/d Birmingham	£27 0 0 to £29 0 0	
	Home.	Export.
Tubes, Solid Drawn, 2/1 Alloy	8½d.	8¾d.
„ Brazed	10¾d.	10¾d.
Tin—		
Cash	£229 15 0 to £229 17 6	
Three months	£229 15 0 to £230 0 0	
Lead:	£10 15 0 to £10 13 9	
Spelter:	£11 18 9 to £12 5 0	
Aluminium Ingots (British)	£100	

FUELS.

SCOTLAND.

Lanarkshire—	Export.
(f.o.b. Grangemouth)—Navigation Unscreened	13/–
„ Glasgow—Ell	15/6
„ „ Splint	16/6 to 17/–
Ayrshire—	
(f.o.b. Ports)—Steam	13/–
Fifeshire—	
(f.o.b. Methil or Burntisland)—Prime Steam	13/6 to 13/9
Unscreened Navigation	12/6 to 13/–
Lothians—	
(f.o.b. Leith)—Hartley Prime	13/–
Secondary Steam	12/6

ENGLAND.

Yorkshire, Manchester—	
B.S.Y. Hard Steams	18/6 to 21/6
Furnace Coke	13/– to 17/6
Northumberland, Newcastle—	
Blyth Best	14/3 to 14/6
„ Second	13/–
„ Best Small	10/6 to 11/–
Unscreened	12/6 to 13/6
Durham—	
Best Gas	14/8
Foundry Coke	18/6 to 22/6

Sheffield	Inland.
Best Hand-picked Branch	24/– to 26/–
South Yorkshire Best	21/– to 23/–
South Yorkshire Seconds	17/6 to 19/–
Rough Slacks	8/– to 9/–
Nutty Slacks	7/– to 8/6

Cardiff— SOUTH WALES.	
Steam Coals:	
Best Admiralty Large	19/6
Seconds	19/– to 19/4½
Best Dry Large	18/9 to 19/3
Ordinaries	18/3 to 18/6
Best Bunker Smalls	13/6 to 14/–
Cargo Smalls	11/6 to 12/6
Dry Nuts	22/– to 26/–
Foundry Coke	24/– to 37/6
Furnace Coke	19/– to 21/6
Patent Fuel	21/–
Swansea—	
Anthracite Coals:	
Best Large	37/6 to 40/–
Machine-made Cobbles	41/– to 51/–
Nuts	40/– to 50/–
Beans	25/– to 30/–
Peas	19/– to 22/6
Rubbly Culm	11/6 to 12/–
Steam Coals:	
Large	17/– to 20/6

FUEL OIL.

Inland consumption; contracts in bulk.
Exclusive of Government tax of 1d. per gallon.

Ex Ocean Installation.	Per Gallon.
Furnace Oil (0·950 gravity)	3½d.
Diesel Oil	4d.

Manchester prices ½d. per gallon extra.

French Engineering Notes.

(From our own Correspondent in Paris.)

Foreign Labour.

MANY of the French industries are in the peculiar position of depending largely on foreign labour, and during some years of development after the Armistice there was an organised importation of labour from Poland and other countries, when international conventions were entered into guaranteeing the same treatment to such workers as that accorded to the French. The home labour supply had been reduced by war losses, and, in normal times, military service absorbs a large contingent of men, so that the great industrial expansion after the war could only be carried on by utilising a labour surplus from other countries. Before the slump began in 1929 official figures show that a million and a half foreign workers were employed in industry, and that during the past four years three-quarters of a million of them have returned to their respective countries, leaving 800,000 at a time when 356,000 French workers are out of employment. These official figures represent a minimum and are believed to be based upon data which are difficult to obtain in the absence of an organised system of national unemployment relief. In order to remove the pressure of foreign labour, employers were at first required to limit the number of foreign hands to 10 per cent. of the total number of men engaged in their establishments, and that percentage was recently further reduced, until now the Government is considering plans that aim at what is practically the elimination of foreign labour. It is proposed that no more foreign workers shall be admitted to this country, and that others shall be weeded out by a non-renewal of permits, though exceptions will doubtlessly be made in the case of those who have settled down in France or whose special services are indispensable. This action would be logical if it were not for the dependence of so many industries upon the skill of specialised foreign workers, as well as upon men accustomed to more arduous occupations in foundries, rolling mills, and other departments of the iron and steel industries, for which it is difficult to procure suitable French labour. A great deal of inconvenience has already been caused by the restriction of foreign labour and the increased cost of production arising out of the tax which manufacturers have to pay for foreigners employed in excess of the number fixed by law. It is feared that the proposal to eliminate foreign labour will reduce employment and defeat the object of the suggested legislation by wiping out some special industries, and it may also affect the future industrial position so long as many branches of production are dependent more or less on foreign labour in times of normal activity.

Military and Civil Aviation.

The programme of the Air Ministry aims at increasing the efficiency of the military and civil air services by a considerable expenditure on aircraft in a manner designed to ensure that the country will always have a force capable of meeting all contingencies. Of the 980 million francs allotted to the Air Ministry, mainly for the construction of new machines, 500 millions have already been spent, and the balance will be carried over to the coming financial year to be added to the normal credits, while Parliament will be asked to vote a special grant of 1000 million francs under the scheme of national defence. The Minister, General Denain, affirms that an expenditure of 3500 millions, in addition to the annual credits of 1500 millions, will be needed to bring the air force to the desired state of efficiency, and it is proposed to prepare a plan of aircraft construction over a number of years in the same way as is done with naval construction. At the beginning of 1935 Germany, it is explained, will have from 1000 to 1100 military aeroplanes of the most efficient types, and while the French machines exceed that number, they are, for the most part, old models. With the credits already available, the Minister hopes that it will be possible to bring French aviation rapidly on a level with German. He further states that the construction of underground aircraft shelters immune from bombardment would involve an expenditure of 2000 million francs. As regards civil aviation the Air Ministry is giving special attention to the organising of Transatlantic services, and negotiations are in progress with Great Britain and the United States for the installation of floating revictualling stations.

The Ecole Centrale.

A very distinguished company, including the President of the Republic and foreign ambassadors, assembled last week at the Ecole Centrale to commemorate three anniversaries—that is to say, the transference of the school to its present site fifty years ago; the death in the same year of the eminent chemist, J. B. Dumas, one of the founders of the school in 1829, and the flight across the Channel by Monsieur Louis Blériot, whose historic aeroplane is preserved in the museum of the Ecole Centrale. The school has a standing second only to that of the Polytechnic, from which it differs by a more comprehensive aim, and engineering, industry, science, and chemistry owe much to the long list of distinguished former students, some of them of international renown. Under the direction of Monsieur Leon Guillet, the high level of the Ecole Centrale has been more than maintained, and Monsieur Guillet was personally responsible for the recent creation of the students' home, which he was able to realise with the aid of funds he collected himself.

Coal Gas for Road Vehicles.

While the use of compressed coal gas for lorries and omnibuses has been experimented with for several years, it was only last week that the first installation for the supply of compressed gas for public and private motor vehicles was put into operation at Cambrai, with gas supplied from coke ovens at the Anzin colliery. The only reason for delay in employing gas compressed to more than a ton per square inch has been the uncertainty regarding the provision of suitable storage cylinders.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

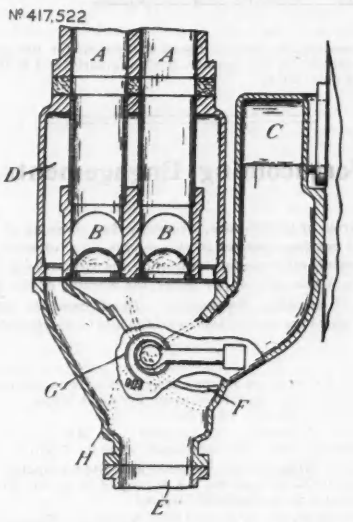
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES.

417,522. April 6th, 1933.—HEATERS FOR THE INTAKE MANIFOLDS OF INTERNAL COMBUSTION ENGINES, Bendix Aviation Corporation, 105, West Adams-street, Chicago, Illinois, U.S.A.

When the engine is being started it is sometimes desirable to warm the combustible mixture, but when the engine is running the warming is unnecessary. The mixture goes to the working



cylinders from the carburetting system A A *viâ* the passages B B. It is warmed by the passage of the exhaust gases from the manifold C, through the jacket D, on their way to the outlet E. During this time the gases are deflected upward by the damper F, which is controlled by the bimetallic element G. When the engine has warmed up this element draws the damper over to the position H, so that the exhaust is direct and there is no pre-heating of the charge.—*October 8th*, 1934.

TELEGRAPHS AND TELEPHONES.

417,378. February 1st, 1933.—INDUCTANCE COILS, The General Electric Company, Ltd., of Magnet House, Kingsway, London, W.C.2, and Henry Cobden Turner and Geoffrey Richard Polgreen, both of Salford Electrical Instruments, Ltd., Peel Works, Silk-street, Salford, and Clive Gordon Smith and Charles Norman Smyth, both of Research Laboratories of The General Electric Company, Ltd., Wembley, Middlesex.

This invention relates to adjustable filter coils, loading coils for telephone circuits, and tuning coils for wireless broadcast receivers. The core consists of two similar parts, one of which is shown in sectional elevation in Fig. 1 and in plan in Fig. 2. Each part consists of a cylindrical pot, open at one end, and having a central cylindrical boss A projecting from the base of the pot to the level of the top of the side wall. Slightly less than half the top surface of the boss is cut away to a level

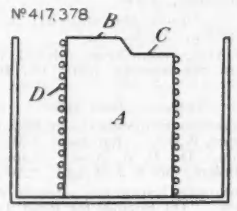


Fig.1

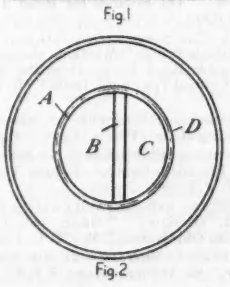


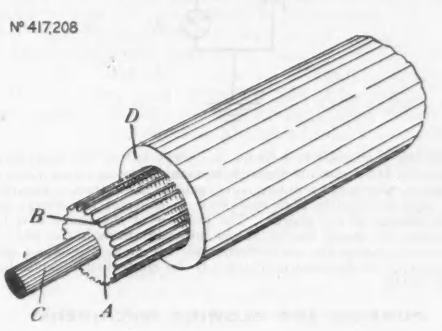
Fig.2

slightly below that of the top of the side wall, so that the top surface of the boss comprises two similar horizontal portions B, C (the part B being on a level with the top of the side wall, and the part C on a slightly lower level), connected by a sloping portion. The two parts of the core, each as shown in the drawing, are arranged one on top of the other with their open ends adjacent to one another, so that each boss is in contact with and forms a continuation of the other, and each side wall is in contact with and forms a continuation of the other. The top part of the core is free to rotate on the bottom part about the axis of the bosses. The coil D is wound around the two bosses, which together form a central limb for the flux. In one position of the top of the core two horizontal portions of the top surfaces of the bosses coincide exactly, and are in contact over their whole area; in this position the reluctance of the magnetic circuit is a minimum. If the top part of the core is rotated relatively to the bottom part, the contact area is gradually decreased, and the reluctance of the magnetic circuit increased, until finally, when the top part has been rotated through 180 deg. relatively to the bottom part, there is a complete air gap between the two bosses and the reluctance is a maximum. The sloping portions of the top surfaces of the two bosses may be so inclined that in the final position the air gap is of substantially uniform width.—*October 7th*, 1934.

TRANSMISSION OF POWER.

417,208. April 27th, 1933.—ELECTRIC CABLES, St. Helens Cable and Rubber Company, Ltd., of St. Helens Works, Slough, Buckinghamshire, and Harry Clifford Harrison, of Little Belmont House, Belmont-road, Maidenhead, Berkshire.

In cables having insulating material of rubber or similar vulcanisable compound and a protective sheath, also of rubber or similar vulcanisable compound, it is often advantageous to incorporate in the sheath some chemical body or bodies for the purpose of conferring special properties on the sheath. In particular, halogenated chemical bodies — for instance, chlorinated naphthalenes—may be embodied in the sheath for the purpose of giving it resistance to fire. An obstacle to the employment of such bodies is their liability to produce lowering of the electric properties, particularly the insulation resistance. This is not of importance in the sheath, but it has

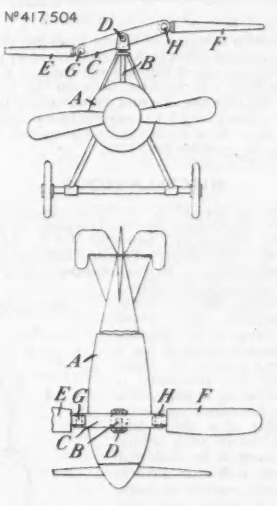


been found that it is liable to spread into the insulating material, and it appears that this takes place during vulcanisation. It is the object of the invention to provide a cable of the kind indicated in which deterioration of the electrical properties of the insulating material is not produced when chemical bodies, capable of producing deterioration, are used in the surrounding sheath. A layer A of rubber constituting the dielectric has small ribs B. The layer A is extruded around a conductor C, and a protective sheath D having a smooth inner surface is extruded over the layer A. The sheath D is made of a rubber compound and contains, for example, a chlorinated naphthalene. In this case the sheath D is separated from the dielectric consisting of the layer A by a discontinuous air space, the ribs B being the only portions of the dielectric with which the inner surface of the sheath D makes contact. The discontinuous air space is made up of the spaces of small depth formed between each pair of adjacent ribs and the inner surface of the sheath D.—*October 1st*, 1934.

AERONAUTICS.

417,504. February 2nd, 1933.—IMPROVEMENTS IN AIRCRAFT, N. V. Instituut voor Aero- & Hydro-Dynamiek, 19, Reguliersgracht, Amsterdam, Holland.

A flying machine with rotary wings of the present invention is characterised by the fact that the wings are articulated for free oscillatory movement in a substantially vertical plane to a balance member mounted on the machine for rotatory and free tilting movement. A is the fuselage and B is the vertical shaft mounted in the fuselage. C is a balance beam or double-armed lever pivoted to the top end of shaft B at D, so as to be able



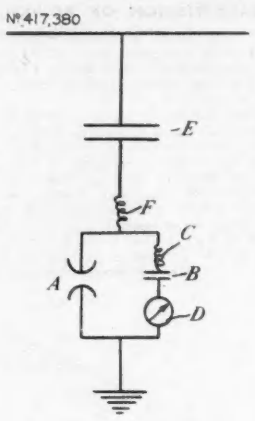
to oscillate in vertical direction. To the ends of the lever C are articulated the wings E and F at G and H for free independent vertical oscillation. Supposing the wings to rotate in clockwise direction, wing F rotating counter to the flying wind will be lifted as shown, and its point of articulation H will be lifted correspondingly, being capable of turning about point D. In consequence thereof the point of articulation G of wing E, which is rotating substantially in the direction of the flying wind, will be depressed together with the wing itself, the centrifugal forces, which act on the two wings, tending to counteract the movement of the balance beam C.—*October 2nd*, 1934.

MEASURING AND TESTING INSTRUMENTS.

417,380. February 28th, 1933.—MEASUREMENT AND INDICATION OF HIGH VOLTAGES, *The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C.2, and Charles Gilbert Mayo, of* 17, *Alexandra-road, Rugby.*

An arrangement is described in this specification for indicating or measuring the voltage on a high-tension conductor by means of the charging current of a condenser connected between the conductor and earth. In parallel with the gap A an oscillatory circuit comprising a capacity B and an inductance C is connected,

the oscillatory circuit, also including a measuring instrument D when a measurement as opposed to an indication is required. A series of inductances may, however, also be included. The capacity of B is small in relation to that of the condenser E. When the breakdown voltage of the gap or tube A is reached, there is an oscillatory discharge round the local circuit C B D A, and the charge energy of the condenser B is ultimately turned into heat in the ammeter D, the gap or neon tube A, and the associated connections. Thus, the quantity of charge supplied

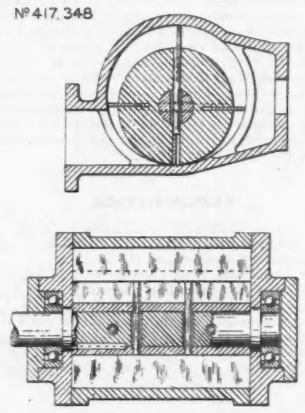


from the condenser E delivers its energy to the low-resistance ammeter D by passing through it many times in an oscillatory manner, whereas in previous constructions the ammeter required to have sufficiently high resistance to abstract the energy at one passage of the charge. The purpose of the choke F is to prevent too great loss of charge directly through the gap A to earth during the oscillation, and the choke C enables the frequency of the local oscillation to be controlled.—*September 28th*, 1934.

PUMPING AND BLOWING MACHINERY.

417,348. July 5th, 1933.—ROTARY EXHAUSTERS, Nichols Compressors, Ltd., 302, Finsbury Pavement House, London, E.C.2; and M. Haggo, Strathearn, Castle Hills, Northallerton, Yorkshire.

In this invention the sliding vanes of rotary exhausters are positively held to the casing wall during the whole of each revolution so that the vanes cannot stick in their slots as some-

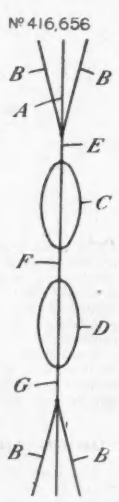


times happens with the type of rotary machine which depends entirely on centrifugal force to keep the vanes in contact with the case. Holes are bored through the body of the rotor and the shaft on which it is mounted between the bottom of one vane slot and the opposite one and sliding across pins or pieces are inserted of correct length to bear on the bottom edges of the vanes and so keep them always correctly spaced with relation to the casing wall.—*October 3rd*, 1934.

MISCELLANEOUS.

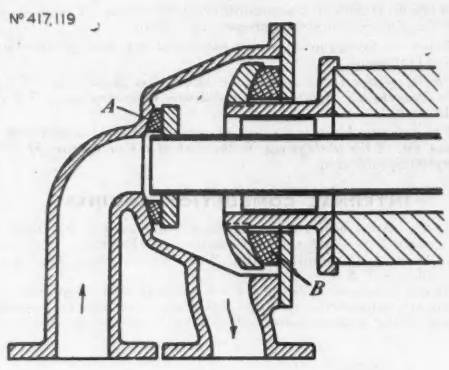
416,656. May 29th, 1934.—FUSIBLE ELECTRIC CUT-OUT ELEMENTS, The English Electric Company, Ltd., of Queen's House, 28, Kingsway, London, W.C.2, Arthur Milnes Pooley, of "Riverdale," Tixall, Stafford, Staffordshire, and Marshall Arthur Britten Landers, of The Rectory, Tixall, Stafford, Staffordshire.

In the English Electric high-rupturing capacity fuse, which forms the subject of another patent, the fusible element has a reduced central section, to which, on account of the reduction in cross-sectional area, a rupture is confined, the invention consisting in forming this of a single conductor in the centre with several branched conductors at each end. In accordance with the present invention, which applies to high-voltage fuses, a single conductor central section of the necessary length for the voltage involved is divided up into a number of short sections by intermediate branched portions of the element. The through conductor A, in addition to being branched at B, as in the previous patent, is formed with intermediate branches C D in the form of loops attached at two points to the single conductor central section, dividing the latter up into portions E F G. Whilst the drawing shows three such sections with two intermediate branched portions, the invention covers any number of such subdivisions.—*September 18th*, 1934.



417,119. February 23rd, 1933.—STEAM INLETS FOR ROTARY CYLINDERS, *W. W. Triggs*, 57, *Lincoln's Inn-fields, London, W.C.2*.

This invention is concerned with the steam connections to the drying rolls of paper-making machines and similar services, where tight joints must be maintained even if the parts do move slightly out of alignment. The joints are, as a consequence, made by the packing rings A and B, which bear against spherical surfaces on the one side and against plain



radial faces on the other. There is freedom for the parts to move relatively to one another, both angularly and radially.—*September 24th*, 1934.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

INST. OF ELECTRICAL ENGINEERS: N. EASTERN STUDENTS.—Armstrong College, Newcastle-upon Tyne. Address, "Application," Mr. L. E. Mold. 7.15 p.m.

INST. OF ELECTRICAL ENGINEERS: S. MIDLANDS.—Grand Hotel, Birmingham. Annual dinner. 6.30 for 7 p.m.

INST. OF MECHANICAL ENGINEERS.—Storey's-gate, S.W.1. Thomas Lowe Gray Lecture, "A Survey of Ships and Engines," Mr. Loughnan St. L. Pendred. 6 p.m.

INST. OF METALS: LONDON LOCAL SECTION.—Thames House, Millbank, S.W.1. Supper-dance. 7.30 p.m. to midnight.

INST. OF PROFESSIONAL CIVIL SERVANTS.—At Royal Soc. of Arts, John-street, Adelphi, W.C.2. Lecture by Mr. A. Keiller. 5 for 5.30 p.m.

INST. OF SANITARY ENGINEERS.—Abercorn Rooms, Great Eastern Hotel, Liverpool-street, E.C.2. Annual dinner. 7.15 p.m.

JUNIOR INST. OF ENGINEERS.—39, Victoria-street, S.W.1. "Steam Plant Foaming and Priming," Mr. C. S. Irving. 7.30 p.m.

N. EAST COAST INST. OF ENGINEERS AND SHIPBUILDERS.—At Mining Inst., Newcastle-upon-Tyne. "The Trend of Destroyer Design," Mr. E. Leslie Champness. 6 p.m.

SATURDAY, DEC. 1ST.

INST. OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH.—Engineers' Club, Manchester. "Foundry Costing," Mr. J. Roxburgh. 4 p.m.

MONDAY, DEC. 3RD.

ENGINEERS' GERMAN CIRCLE.—At Inst. of Mechanical Engineers, Storey's-gate, S.W.1. "Automatic Welding Machines." 5.15 for 6 p.m.

INST. OF ELECTRICAL ENGINEERS: S. MIDLANDS.—James Watt Memorial Inst., Birmingham. "Generation, Distribution, and Use of Electricity on Board Ship," Messrs. C. W. Saunders, and H. W. Wilson, and Dr. R. G. Jakeman. 6.15 for 6.30 p.m.

INST. OF STRUCTURAL ENGINEERS: JUNIOR SECTION.—10, Upper Belgrave-street, S.W.1. "Modern American Buildings," Mr. D. Bethune Williams. 7 p.m.

ROYAL INST. OF GREAT BRITAIN.—21, Albemarle-street, W.1. General meeting. 5 p.m.

ROYAL SOC. OF ARTS.—John-street, Adelphi, W.C.2. Cantor Lecture, "Modern Spectroscopy (iii)," Dr. Hubert Dingle. 8 p.m.

TUESDAY, DEC. 4TH.

INST. OF AUTOMOBILE ENGINEERS.—At Royal Soc. of Arts, John-street, Adelphi, W.C.2. "Functions of Mechanical Power in Soil Cultivation," Dr. B. A. Keen; "Some Features of Modern Tractor Design," Mr. S. J. Wright. 7.30 p.m.

INST. OF AUTOMOBILE ENGINEERS.—James Watt Memorial Inst., Birmingham. "Oil Engines for Road Transport," Mr. H. O. Farmer. 8 p.m.

INST. OF CIVIL ENGINEERS.—Great George-street, S.W.1. Discussion, "Lambeth Bridge," Mr. G. L. Groves; "Construction of a Submergible Road Bridge Over the Nerbudda River near Jubbulpore, Central Provinces, India," Mr. A. W. H. Dean. 6 p.m.

INST. OF ELECTRICAL ENGINEERS: LONDON STUDENTS.—Visit to Broadcasting House, Portland-place, W.1. 1.30 p.m.

INST. OF ELECTRICAL ENGINEERS: N. MIDLAND.—Queen's Hotel, Leeds. "Electrical Control of Road Traffic by Vehicle Actuation," Mr. T. P. Preist. 7 p.m.

INST. OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—39, Elmbank-crescent, Glasgow. "Marine Slipways: Unusual Developments of an Old System," Mr. W. G. Glover. 7.30 p.m.

ROYAL INST. OF GREAT BRITAIN.—21, Albemarle-street, W.1. "The Solid State," Sir William Bragg, F.R.S. 5.15 p.m.

WEDNESDAY, DEC. 5TH.

INST. OF BRITISH FOUNDRYMEN: PRESTON SECTION.—Technical College, Corporation-street, Preston. "Foundry Troubles," Mr. C. C. Hodgson. 7.30 p.m.

INST. OF CIVIL ENGINEERS: STUDENTS.—Great George-street, S.W.1. Informal meeting. Discussion, "Modern Road Design," Mr. A. L. Somerville. 6.30 p.m.

INST. OF ELECTRICAL ENGINEERS: WIRELESS SECTION.—Savoy-place, W.C.2. "Some Principles Underlying the Design of Spaced-aerial Direction-finders," Mr. R. H. Barfield. 6 p.m.

INST. OF METALS: LONDON LOCAL SECTION.—Charing Cross Hotel, W.C.2. Joint meeting with Inst. of British Foundrymen "Manganese Bronze," Mr. Wesley Lambert. 8 p.m.

NORTH-EAST COAST INST. OF ENGINEERS AND SHIPBUILDERS: GRADUATE SECTION.—Bolbec Hall, Newcastle-upon-Tyne. "The Early Theories of Superheated Steam," Mr. G. M. Baker. 7.15 p.m.

THURSDAY, DEC. 6TH.

INST. OF CIVIL ENGINEERS: BIRMINGHAM AND DISTRICT ASSOC.—Visit to Droitwich Transmitting Station of British Broadcasting Corporation. 3 p.m.

INST. OF ELECTRICAL ENGINEERS.—Savoy-place, W.C.2. "A Critical Examination of the Present Practice relating to the Electrical Warming and Air-conditioning of, and the Supply of Hot Water to, the Larger Building," Messrs. R. Grierson and D. Betts. 6 p.m.

INST. OF ELECTRICAL ENGINEERS: S. MIDLAND STUDENTS.—Visit to works of Metropolitan Cammell Carriage, Wagon and Finance Company, Ltd., Saltley, Birmingham. 2.30 p.m.

INST. OF MARINE ENGINEERS: JUNIOR SECTION.—At L.C.C. School of Navigation, Poplar, E.14. "The Work of the William Froude Experimental Tank," Mr. J. L. Kent. 7 p.m.

INST. OF MECHANICAL ENGINEERS: N. WESTERN BRANCH.—Engineers' Club, Manchester. Annual dinner.

ROYAL AERONAUTICAL SOC.—At Royal Soc. of Arts, John-street, Adelphi, W.C.2. "Recent Progress of the Autogiro," Senor Juan de la Cierva. 6.30 p.m.

FRIDAY, DEC. 7TH.

BELFAST ASSOC. OF ENGINEERS.—Queen's Hotel, Belfast. Smoking concert. 8 p.m.

INST. OF MECHANICAL ENGINEERS.—Storey's-gate, S.W.1. Informal meeting. 7 p.m.

JUNIOR INST. OF ENGINEERS.—39, Victoria-street, S.W.1. "Geometrical Constants," Dr. W. N. Bond. 7.30 p.m.

ROYAL INST. OF GREAT BRITAIN.—21, Albemarle-street, W.1, Discourse, "The Crystallisation of Alloys," Dr. C. H. Desch. F.R.S. 9 p.m.

SATURDAY, DEC. 8TH.

INST. OF ELECTRICAL ENGINEERS: LONDON STUDENTS.—Visit to works of British Oxygen Company, Ltd., Edmonton. 10 a.m.

INST. OF ELECTRICAL ENGINEERS: N. MIDLAND STUDENTS.—Visit to works of John Fowler and Co. (Leeds), Ltd., Leeds. 2.30 p.m.

INST. OF MARINE ENGINEERS.—The Minories, E.C.3. Junior Section social and dance. 7.30 p.m.

STEPHENSON LOCOMOTIVE SOC.—King's Cross Station, N.1. Annual general meeting, 3 p.m., Midland Grand Hotel, St. Pancras, N.W.1. Annual dinner, 6.30 p.m.

MONDAY, DEC. 10TH.

CHADWICK PUBLIC LECTURES.—London School of Hygiene, Keppel-street, Gower-street, W.C.1. "Men and Masses," Dr. F. R. Seymour. 5.30 p.m.

INST. OF METALS: SCOTTISH LOCAL SECTION.—At 39, Elmbank-crescent, Glasgow. "Improvements in Surface Condenser Tubes," Mr. A. Spittle. 7.30 p.m.

TUESDAY, DEC. 11TH.

INST. OF AUTOMOBILE ENGINEERS.—King's Head Hotel, Coventry. "Electric Discharge Lamps and the Application to Road Lighting," Messrs. H. Warren and L. J. Davies. 7.30 p.m.

INST. OF BRITISH FOUNDRYMEN: BURNLEY SECTION.—Municipal College, Ormerod-street, Burnley. "Points for Practical Foundrymen," Mr. A. Jackson. 7.15 p.m.

INST. OF MARINE ENGINEERS.—The Minories, E.C. "Gears for Marine Main and Auxiliary Drives," Dr. H. E. Merritt. 6 p.m.

INST. OF METALS.—Y.M.C.A., Swansea. "Refractory Materials of South Wales," Professor W. R. D. Jones. 6.15 p.m.

WEDNESDAY, DEC. 12TH.

BELFAST ASSOC. OF ENGINEERS.—Queen's Hotel, Belfast. "Power Transmission by Flat and 'V' Belts," Mr. S. B. Hainsworth.

INST. OF CIVIL ENGINEERS.—Great George-street, S.W.1. Informal meeting. Discussion, "Modern Developments in Variable Transmission Gears," Dr. H. S. Hele-Shaw. 6 p.m.

INST. OF MECHANICAL ENGINEERS.—Graduates' visit to Cadby Hall of J. Lyons and Co., Ltd.

THURSDAY, DEC. 13TH.

INST. OF CIVIL ENGINEERS: BIRMINGHAM AND DISTRICT ASSOC.—Queen's Hotel, Birmingham. Annual dinner. 6.30 for 7 p.m.

INST. OF LOCOMOTIVE ENGINEERS.—At Inst. of Mechanical Engineers, Storey's-gate, S.W.1. Informal meeting. 6 p.m.

INST. OF STRUCTURAL ENGINEERS.—10, Upper Belgrave-street, S.W.1. "The Code of Practice for Reinforced Concrete," Mr. C. E. Reynolds. 6.30 p.m.

ROYAL AERONAUTICAL SOC.—At Royal Society of Arts, John-street, Adelphi, W.C.2. "Recent Research in Metallurgy," Dr. W. H. Hatfield. 6.30 p.m.

FRIDAY, DEC. 14TH.

CHEMICAL ENGINEERING GROUP.—Rooms of Chemical Soc., Burlington House, W.1. "Chemical Aspect of Timber Research," Mr. W. G. Campbell. 8 p.m.

INST. OF ELECTRICAL ENGINEERS: S. MIDLAND STUDENTS.—Boot's Café, Colmore-row, Birmingham. Annual dance.

INST. OF MECHANICAL ENGINEERS.—Storey's-gate, S.W.1. "A General Comparison of Gas and Electricity for Heat Production," Mr. A. H. Barker. 6 p.m.

INST. OF METALS: SHEFFIELD.—The University, St. George's-square, Sheffield. "Rhodium Plating and its Application," Mr. A. W. Scott. 7.30 p.m.

JUNIOR INST. OF ENGINEERS.—At Royal Soc. of Arts, John-street, Adelphi, W.C.2. Inaugural meeting, "The Lighting of Streets and Roadways, with special Reference to Safety," Mr. C. C. Paterson. 7.30 p.m.

ROYAL SOC. OF ARTS.—John-street, Adelphi, W.C.2.—"Indian Forestry: Economic and Commercial Aspects," Mr. A. D. Blascheck. 4.30 p.m.

FRIDAY AND SATURDAY, DEC. 14TH AND 15TH.

BOROUGH POLYTECHNIC.—Borough-road, S.E.1. Exhibition of Students' Works. Friday, 6–9 p.m.; Saturday, 2.30 to 9.30 p.m.

LAUNCHES AND TRIAL TRIPS.

DORSET, twin-screw motor ship; built by Workman, Clark (1928), Ltd., to the order of Federal Steam Navigation Company, Ltd.; to carry cargo. Engines of Sulzer-Diesel type; constructed by Sulzer Bros., Winterthur; handed over to owner.

W. H. FULLER, steel twin-screw tug; built by Harland and Wolff, Ltd., to the order of the South African Railways and Harbours; dimensions, 145ft. by 32ft. by 16ft.; for deep sea towing and salvage work. Engines, triple-expansion. The tug left for South Africa, November 9th.

SAN AMADO, motor vessel; built by Blythswood Shipbuilding Company, Ltd., to the order of Eagle Oil and Shipping Company, Ltd.; dimensions, 460ft. by 60ft. by 32ft.; to carry oil in bulk. Diesel engines, Burmeister and Wain type; constructed by John G. Kincaid and Co., Ltd.; launch, November 21st.

TAROONA, geared turbine vessel; built by Alexander Stephen and Sons, Ltd., to the order of Tasmanian Proprietary, Ltd.; dimensions, 335ft. by 50ft. by 26ft.; to carry passengers. Engines, Parsons geared turbines, pressure 400 lb. per square inch; launch, November 22nd.

A Seven-Day Journal

Research in Atmospheric Pollution.

LAST week thirty-two representatives of local authorities and other organisations co-operating with the Department of Scientific and Industrial Research in the investigation of atmospheric pollution met in London for the half-yearly conference at the offices of the Department. The gathering included representatives from London, Manchester, Glasgow, Liverpool, Southampton, Leicester, Newcastle, Hull, Scarborough, Halifax, Lancaster, Leamington, and Wolverhampton. The conference, over which Councillor W. Brownhill-Smith, of Glasgow, presided, received a report from Dr. G. M. B. Dobson, F.R.S., on the progress of the researches carried out under the Atmospheric Pollution Research Committee. Dr. Dobson stated that the new method which had been developed at the Building Research Station for estimating sulphur in the atmosphere was now being used at twenty-seven stations. It was hoped that it would be adopted still more widely by local authorities, as it gave, he said, with little expense, information of great value concerning one of the most destructive of atmospheric impurities. He also referred to trials which were being made of a photo-electric method for recording daylight. If successful, this new method would, Dr. Dobson stated, provide a virtually automatic means for measuring the amount of the sun's ultra-violet light which is cut off by smoke haze, and would thus provide further information as to the actual sunlight received in smoke-polluted areas. The conference agreed that the subject of atmospheric pollution needed much greater public attention than it was now receiving, and that the scientific investigation of it should receive the support of all local authorities.

Broadcasting Station for Weather Reports.

A NATIONAL aviation meteorological station, the programmes of which will consist only of weather reports, weather forecasts, and warnings for airmen, is to be erected by the Marconi Company on behalf of the Air Ministry at Cranwell, in Lincolnshire. The new station will be operated by the Air Ministry and will transmit meteorological bulletins at regular intervals throughout the day for the information of aircraft and aerodromes. It will have an energy of 2 kilowatts in the aerial, or several times the power of the present Heston station, which transmits aviation weather reports, and its messages are expected to be easily receivable over a wide area in Great Britain. No interference will be caused with B.B.C. programmes, for the Cranwell station will operate on the wave length now used by Heston, which it will supersede, namely, 1158 m. (253 kilocycles). It is hoped that this important extension of the present meteorological services of the Air Ministry will be of practical utility to pilots, air line operating companies, and flying clubs throughout the country, enabling them to receive regular and authoritative weather reports, &c., without difficulty and without delay. The station is expected to be opened in the early summer of 1935. Its transmitter will be of the type supplied by the Marconi Company to a number of broadcasting authorities in various parts of the world. While the station itself will be established at Cranwell, Lincolnshire, in order to obtain the advantages of a central situation for a "national" weather report service, the actual announcing will be done from the Meteorological Office of the Air Ministry in London.

The South-West England and South Wales Electricity Scheme.

ON Saturday, December 1st, the Central Electricity Board issued particulars of the alteration and extension scheme that it has adopted for South-West England and South Wales. Comprising an area of 17,090 square miles, it covers the largest of the areas for which schemes have been introduced, but while it represents about 25 per cent. of the total area covered by all the schemes, the population of approximately 6½ millions is only about 14 per cent. of that of Great Britain. Under the original scheme adopted by the Board in May, 1930, seven existing generating stations were selected for permanent operation, while provision was made for the erection of two new selected stations as required, one on Southampton Water and one at Swansea. The new alteration and extension scheme received from the Electricity Commissioners in October provides for the selection of a further seven existing stations, and brings the total number contemplated for the area up to sixteen, the construction of the new station on Southampton Water being meanwhile postponed. The Portishead station of the Bristol Corporation, with an installed capacity of 90,000 kW, is at present the largest in the area, and, like the new Tir John North station of the Swansea Corporation, in which the initial 70,000 kW of plant will be brought into operation next year, is designed for extension to a capacity of 240,000 kW. The other selected stations are Cardiff (Cardiff Corporation), Hayle (Cornwall Electric Power Company), Newton Abbot (Torquay Corporation), Newport (Newport Corporation), Plymouth (Plymouth Corporation), Portsmouth (Portsmouth Corporation), Southampton (Southampton Corporation), Upper Boad (South Wales Electrical Distribution Company), Bath (Bath Corporation), Exeter (Exeter Corporation), Morden (Swindon Corporation), Llanelly (Llanelly and District Electric Supply Company, Ltd.), and Lydney (West Gloucestershire Power Company, Ltd.).

A New Railway Speed Record.

ON Friday, November 30th, the London and North-Eastern Railway Company arranged for a non-stop run to be made from King's Cross to Leeds and back under scheduled conditions which closely approached those for the "Flying Hamburger" oil-electric train service between Berlin and Hamburg. The locomotive chosen was not of the latest or most powerful type, and was the "Flying Scotsman," "No. 4472," in charge of driver Sparshott and fireman Webster. A double record was set up. On the outward journey the train, which consisted of a dynamometer car, a first-class corridor coach, a dining car, and a brake van, weighing together about 145 tons, left King's Cross at 9.8 a.m. Leeds was reached at 11.39, in 2 h. 31 min., or 14 min. less than the schedule and 42 min. less than the regular run. The average speed for the 185¾ miles was 73·8 miles per hour, and between Hitchen and Huntingdon a speed of 95 miles per hour was attained. On the return trip two further corridor coaches were added to the train, bringing its weight up to approximately 205 tons. Leaving Leeds at 2 p.m., King's Cross was again reached at 4.37, or 8 min. ahead of the scheduled time. Near Essendene a speed of 100 miles per hour was reached. Mr. H. N. Gresley and Mr. V. M. Barrington-Ward, the superintendent of the Western Division, and the crew of the train are to be warmly congratulated on the new speed records set up. We hope to give full particulars of the runs in our next issue.

The Central Electricity Board's New Chairman.

IN consequence of the resignation of Sir Andrew Duncan on his appointment as independent chairman of the British Iron and Steel Federation, Sir Archibald Page has been selected to succeed him as Chairman of the Central Electricity Board. Born in Alloa, Scotland, in 1875, Sir Archibald received his early education at the Dollar Academy, the Heriot-Watt College, Edinburgh, and the Royal Technical College, Glasgow. He became associated with the electricity supply industry as a member of the staff of the Glasgow Corporation Electricity Department, and eventually was appointed Deputy City Electrical Engineer. In 1917 he was made assistant general manager of the Clyde Valley Electric Power Company, and within a short time became general manager. When the Electricity Commission was constituted by Parliament in 1920, Sir Archibald was chosen to act as one of the five commissioners, and occupied that position with distinction for nearly five years, at the end of which he relinquished the post to become a director and general manager of the County of London Electric Supply Company. On the passing of the Electricity (Supply) Act, 1926, Sir Archibald was invited in 1927 to act as the Chief Engineer and Manager of the Central Electricity Board, and subsequently became General Manager. During his association with the Board, the grid system was completed and brought into operation. Sir Archibald has been a member of the Institution of Electrical Engineers for many years, and during the session 1927–28 he occupied the presidential chair. He is also a member of the Institution of Civil Engineers, and a Fellow of the American Institute of Electrical Engineers.

The Development of Civil Aviation.

ON Monday, December 3rd, further information was made available concerning a deputation representing the Parliamentary Air Committee and consisting of Rear-Admiral Sir Murray Sueter, Mr. O. E. Simmonds, Mr. B. Whiteside, Captain F. E. Guest, and Commander Oliver Locker-Lampson, which waited upon the Prime Minister and the Marquis of Londonderry on Tuesday, November 27th, and presented a policy for the future development of civil aviation. With regard to administration, the Committee suggested that a second Under-Secretary of State should be appointed to deal exclusively with civil aviation, and that the Director of Civil Aviation should, as recommended by the Gorell Committee, be a member of the Air Council. In regard to Imperial communications, the following reforms were proposed:—Immediate provision for improved ground organisation, including emergency landing grounds, wireless beacons, and night-flying equipment; the speeding up of the services on Imperial air routes by increased air speeds and night flying was suggested. It was further proposed that there should be an increased frequency of services. The Committee put forward the view that no new obligations to Imperial Airways, Ltd., should be undertaken by the Government which would preclude its financial encouragement of other British aircraft-operating companies. Among other points raised it was suggested that an energetic investigation of trans-oceanic air services should be undertaken. We understand that the deputation had a very sympathetic reception.

Heavy-Oil Engines for Lifeboat Service.

WE are informed by the Royal National Lifeboat Institution that it has decided to call for tenders for a pair of light, high-speed, heavy-oil engines, which will be installed in a new lifeboat which will probably be laid down in the near future. Up to the present all the motor lifeboats in the Institution's fleet, numbering 124, are propelled by petrol engines. In the past the reason for adopting petrol fuel has been that, although heavy-oil fuel is less inflammable and the fire risk is much smaller, the ordinary heavy-oil engine, with its comparatively low speed of revolution, has generally been too heavy for lifeboat service. Recently, however, the speed of heavy-oil engines has been greatly increased, and as a result the weight of such engines is little more than that of petrol engines of the same power. For the past nine months the Institution has been experimenting with a six-cylinder engine of 85 b.h.p., running at 1600 r.p.m., and weighing 26½ cwt., which was designed and built by the Ferry Engine Company, Ltd., of Woolston, Southampton, and was installed in a reserve lifeboat. It is of a water-tight design, and was tested in a flooded engine-room for an hour, during which time it was stopped and started again. Since completing its trials the heavy-oil engine-propelled boat has been stationed both at Weymouth and at Falmouth, where it took the place of the regular boats during the time they were being overhauled. It has now been allocated to Yarmouth, in the Isle of Wight, on permanent duty.

A New Grid Tariff.

THE Central Electricity Board has notified authorised undertakers in South-West England and South Wales that general trading under a grid tariff in accordance with the provisions of the Electricity (Supply) Act, 1926, will begin on January 1st, 1935. The new tariff takes the usual form, and in respect of one or the first point of supply there is no service charge, the grading of the fixed kilowatt charge for each point of supply based on the now well-known method being £3 10s., £3 5s., £3, and £2 15s. If the average power factor of the supply be less than 0·85 lagging during the half-hour in which the maximum demand occurred, the fixed charge will be increased in that year at the rate of 4s. 6d. for each 0·1 by which such power factor shall be below 0·85, and a *pro rata* increase will be made for any part of 0·1. The paragraph covering the variation governed by rates shows that the fixed charge is increased or reduced at the rate of 2s. for each shilling by which the sum arrived at by the usual method shall be above or below 4s. 6d. For each kilowatt supplied and taken during the year the sum of 0·225d. is to be paid, and if the usual coal cost calculation gives a sum of more or less than 14s. 6d. the running charge will be increased or reduced in that year by 0·0008d. for each penny by which the sum is above or below 14s. 6d. As before a halfpenny or any greater part of a penny is treated as a penny, whilst in the case of the rates variation of the fixed charge a *pro rata* increase or reduction is made for any part of one shilling.

Aid for Tramp Shipping.

THE shipowners having submitted a scheme for the reorganisation of their industry and the distribution of the proposed subsidy, the Government, on Friday last, issued as a White Paper the terms on which it proposes to grant assistance to tramp shipping. The amount of the subsidy is not to exceed £2,000,000, and will be reduced below this figure should the average level of freight rates during the subsidy year rise above 92 per cent. of the average level in the year 1929. The subsidy is to be payable for the period of one year, namely, January 1st to December 31st, 1935, and it will be subject to withdrawal within that period if the circumstances which led to its introduction are altered. A Statutory Committee, styled the Tramp Shipping Subsidy Committee, is to be appointed to administer the subsidy and advise the Board of Trade. The cost of administration will, it is expected, not exceed £10,000. Particulars are also given of the modifications which have now been made to the earlier proposals for the scrapping, rebuilding, and modernising of British cargo vessels. Owners are now required to scrap only 2 tons for every ton of new shipping built, and 1 ton for every ton of existing shipping modernised, instead of 3 tons in each case. Owners are also allowed to buy ships from foreign owners for scrapping, as well as to scrap British ships. Advances made for the purpose of building or modernising cargo vessels under the scheme are not to exceed in the aggregate £10,000,000, which is approximately the cost of constructing 1 million deadweight tons of modern cargo shipping. No advance is to be made after the expiration of two years from the date of passing the necessary legislation. The sum of £3000 is given as the probable estimated annual cost of administering the scheme.

THE FISH DOCKS AT GRIMSBY

FIG. 1—OLD FISH DOCKS AND WORK IN PROGRESS ON THE NEW DOCK

FIG. 2—NEW FISH DOCK, SEPTEMBER, 1934, LOOKING WEST

The New Fish Dock, Grimsby.

No. I.

THE necessity for additional dock accommodation to meet the increasing demands of the fishing industry at Grimsby made itself felt fully a quarter of a century ago. In 1912 the Great Central Railway Company, the then owners of the dock system, obtained the sanction of Parliament to construct a new dock. A contract for this work was about to be placed when war broke out in 1914, and the project was abandoned. The new dock at Grimsby, opened on October 4th last by Sir Henry Betterton, is the outcome of the proposals for increased accommodation which were revived in 1928.

The present form of the fish docks at Grimsby dates from the early part of last century, when No. 1 Fish Dock, having a water area of 13 acres, was constructed, followed about twenty years later by No. 2 Dock, which was subsequently enlarged to an area of 16 acres. These two docks are joined by a communicating passage, and are served by two lock entrances, 30ft. and 35ft. wide respectively, between No. 1 Dock and the river Humber. The fish market quays, having a total length of about 1 mile, occupied the whole of the west sides of both docks, whilst the coaling appliances and two graving docks took up half the length of the existing east side, thus leaving little accommodation for trawlers while taking on stores, ice, &c., and while undergoing minor repairs and general outfitting.

At the end of the war the need for a new dock had become greater than ever, but, as the cost of construction had risen by 1920 to approximately 1¼ million pounds, as compared with £500,000 in 1912, the railway company felt that it could not then proceed with the extensions for which powers had been obtained before the war. In 1923 the Great Central Railway was absorbed into the London and North-Eastern Railway under the Railways Act of 1921, and in 1928, as a result of further representations by the Corporation of Grimsby and the trawler owners, it was arranged that the Corporation should build the dock, borrowing money for the purpose, and that the railway company should undertake to operate and to pay a rent for the dock equivalent to the annual payments for interest and sinking fund on the loan, the dock becoming its property when the loan was finally repaid. Since the Grimsby Corporation was to be chiefly responsible for the building of the new dock, the Government agreed to sanction a grant towards the interest payment on the loan for the purpose of assisting unemployment, both in Grimsby and in the depressed areas.

A Bill was promoted in Parliament by the Corporation of Grimsby acting in conjunction with the London and North-Eastern Railway Company, and the Royal Assent was given on May 10th, 1929. Some delay occurred in inviting tenders for the work, owing to the death in April, 1930, of Mr. J. A. Wickham, the chief docks engineer to the railway company, who had

up to that time been responsible for the design. In June, 1930, Sir John Wolfe Barry and Partners were appointed jointly by the Corporation and the railway company as the engineers responsible for carrying out the work and Mr. A. E. Tarrant, Assoc. M. Inst. C.E., has acted as their resident engineer throughout the work. The main contract for the new dock was let to Sir Lindsay Parkinson and Co., Ltd., in November, 1930, and work was commenced in the same month. Mr. A. E. Parkinson was the contractors' agent on the works.

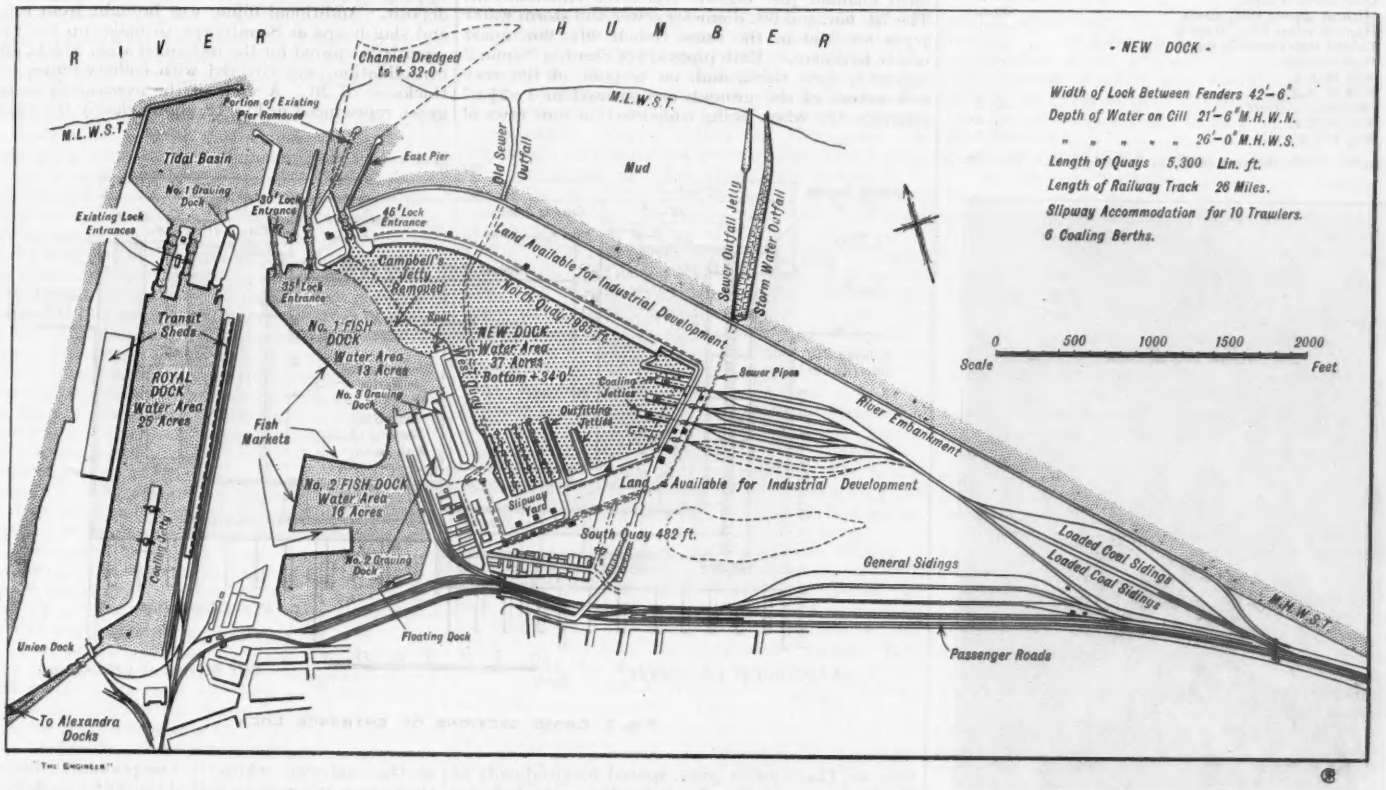


FIG. 3—GRIMSBY FISH DOCKS—GENERAL PLAN

The fish docks at Grimsby are situated to the east of the group of docks which includes the Royal, Union, and Alexandra docks, having a combined water area of about 75 acres, which are used mainly for coal export, timber imports, and general trade. The approach to both groups of docks is through the Grimsby Inner Road, on the south side of the Humber estuary, having a least depth of about 10ft. at M.L.W.S.T., the mean range at spring tides being about 18·75ft. The foreshore in the neighbourhood of the dock entrance is a wide expanse of mud, and the estuary of the Humber between Grimsby on the south side and Sunk Island on the north side has a width of about 4 miles.

GENERAL DESCRIPTION OF THE DOCK.

The new fish dock (plan, Fig. 3) has been built on the foreshore to the east of the existing docks, being now joined to No. 1 Fish Dock by the removal of the greater part of the old Campbell's Jetty, and, by adding a water area of 37 acres, brings the total area of the fish docks up to 66 acres. The additional water area is, however, only a part of the total area of 175 acres enclosed by the new river embankment, the reclaimed land being required for general and coal sidings and for future industrial development. A new entrance lock, 45ft. wide and 204ft. long, with three pairs of gates, has been built near the old entrance. The main quay runs parallel to the river embankment, and is about 2000ft. long, while on the south side there is a similar quay, about 690ft. long, from which project two outfitting jetties, one equipped with a 15-ton crane and the other with a 5-ton crane. For under-water repair work, painting, &c., three slipways are provided serving a slipway yard of ten berths constructed on a side-traversing system. The three coaling appliances are designed to serve the coal direct from the railway trucks to the trawlers, and are capable of coaling six ships at one time. Provision for an additional coaling appliance has been made should the need arise. To eliminate level crossings the access road to the dock from Humber-street is carried over the railway company's main lines and sidings on a reinforced concrete bridge of 5 spans, with a long approach at each end to gain the necessary head-room.

The foreshore on which the dock was constructed was covered to a depth of about 4ft. at high water neap tides and about 8ft. at high-water spring tides, while at low water the tide recedes to a considerable distance from the site. The level of the dock bottom is about 19ft. below the foreshore level, and to enable the excavation and the construction of the various structures to be done in the dry, it was first of all necessary to enclose the whole site by a river embankment. At the same time, the Grimsby main sewer, the storm-water outfall, and the discharge from graving docks Nos. 2 and 3, all of which emptied into an open channel running across the site of the new dock, had to be diverted. These two works, together with the construction of a steel sheet pile and chalk dam beyond the outer end of the new entrance lock, took 1½ years to complete, all being finished by May, 1932, when the bank was finally closed. The views reproduced on page 558 show the old fish docks and work in progress on the new dock (Fig. 1), and the new dock just before its inauguration in October last (Fig. 2). In this aerial view, for which we are indebted to the *Grimsby Evening Telegraph*, is seen in the distance the entrance to the Royal Dock, and in the foreground the new coaling jetties not yet completed.

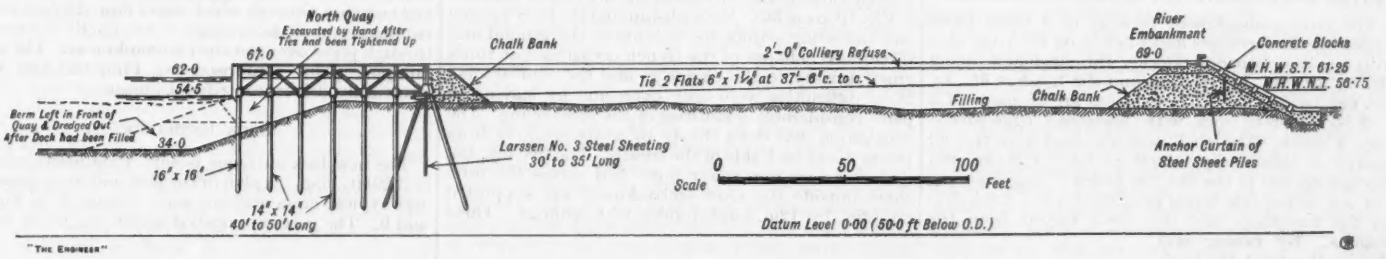


FIG. 4—SECTION THROUGH NORTH QUAY AND RIVER EMBANKMENT

FIG. 5—RIVER EMBANKMENT—FACING WITH CONCRETE BLOCKS—APRIL, 1932

The data relative to tidal levels, &c., set out hereunder will enable the reader clearly to follow the references to levels in this description and in the drawings which we reproduce :

	Above dock datum, feet.
Quay level of dock	67·0
Highest known tide, about	66·0
Highest water level in dock	62·0
Lowest water level in dock	54·5
Dock bottom	34·0
M.H.W.S.T.	61·25
M.H.W.N.T.	56·75
Ordnance Datum	50·0
M.L.W.N.T.	47·0
M.L.W.S.T.	42·5

Grimsby dock datum is 50ft. below O.D. The dock

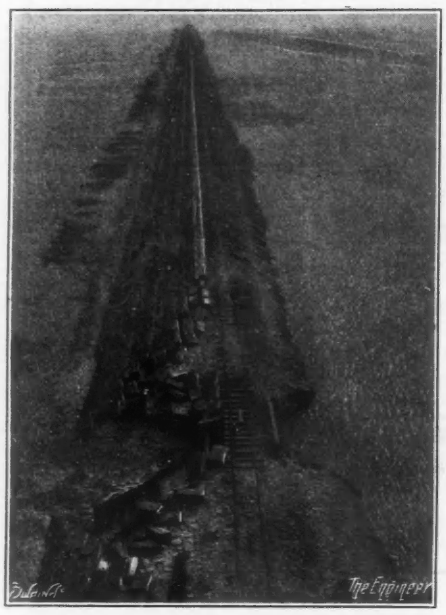


FIG. 6—RIVER EMBANKMENT AND SLUICEWAY —MARCH, 1932

water levels are controlled by opening and closing the gates before and after high water.

RIVER EMBANKMENT AND OUTFALL DIVERSIONS.

The river embankment consists of a chalk bank tipped on the foreshore and pitched on the river face with pre-cast concrete blocks, the stretchers being 6ft. by 3ft. 3in. by 1ft. 3in. and the headers 6ft. by 1ft. 6in. by 2ft. 6in. These blocks are all made of a 1 : 3 : 6 concrete mix with limestone aggregate—Figs. 4 and 5. The chalk was obtained from the old quarry at Brocklesby, about 12 miles distant, and brought by rail to the site, the trains of wagons being run out, when tide levels permitted, on a track laid on the foreshore, and the chalk tipped from the wagons. By raising and slewing this track the bank was gradually built up to the required level. During the construction a considerable amount of chalk was washed away and damage done to the contractors' plant by occasional storms, but no serious breach occurred in the embankment. The treacherous nature of the foreshore soil between the main sewer diversion and the new lock entrance was, moreover, the cause of considerable slips and loss of chalk. For the final closure of the bank two controlled sluices were built between two rows of steel sheet piling and when as much water as possible had drained out of the dock at low tide the gap was rapidly filled in with chalk and clay. The total length of the embankment is about 1¼ miles ; a view of it and of the sluiceway just before the final closing is seen in Fig. 6. The average foreshore level on the line of the river embankment is +51·0ft. and the top of the bank is at +69·0ft. The river face has a slope of 1 in 2 and that on the inside 1 in 1½. At high tides with easterly wind waves run up the slope and over the top. A reinforced concrete wall, 2ft. high, has therefore been built on the crest of the embankment to check the run of the sea.

The new sewer and storm water pipes start from a point near the ends of graving dock No. 3 and run behind the slipway yard and quays. The sewer up to the river embankment is a 7ft. 6in. diameter concrete pipe, its total length being 2700ft.; from this point it is continued across the foreshore for a length of 950ft. in two cast iron pipes, 5ft. 4in. in diameter, laid side by side, which discharge into an open channel. The storm water and discharge from the graving docks are taken by a 6ft. diameter concrete pipe laid parallel to the sewer and discharged into an open channel just outside the river embankment. The 7ft. 6in. and 6ft. diameter sewer and storm water pipes are laid in the same trench, 9ft. 6in. apart centre to centre. Both pipes are of Stanton "spun" concrete, 4½in. thick, and, on account of the very soft nature of the ground, are encased in 1 : 3½ : 7 concrete, the whole being supported on four rows of

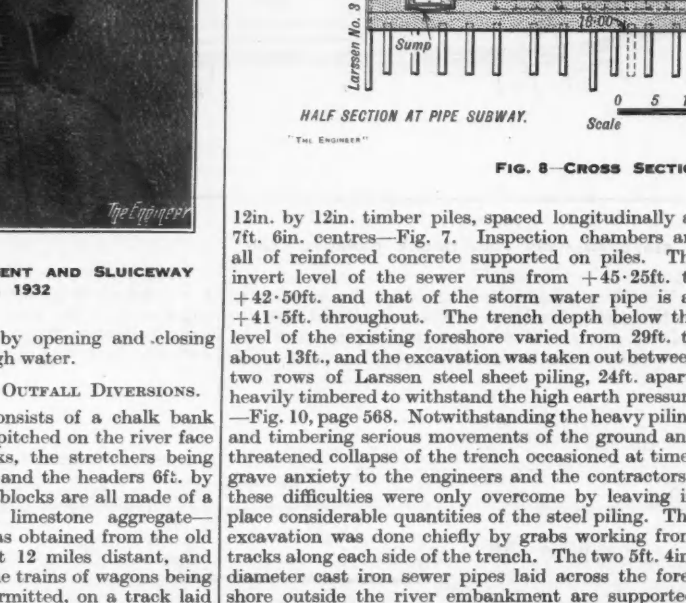


FIG. 7—CONCRETE PIPES, 7FT. 6IN. AND 6FT. DIAMETER—JUNE, 1931

12in. by 12in. timber piles, spaced longitudinally at 7ft. 6in. centres—Fig. 7. Inspection chambers are all of reinforced concrete supported on piles. The invert level of the sewer runs from +45·25ft. to +42·50ft. and that of the storm water pipe is at +41·5ft. throughout. The trench depth below the level of the existing foreshore varied from 29ft. to about 13ft., and the excavation was taken out between two rows of Larssen steel sheet piling, 24ft. apart, heavily timbered to withstand the high earth pressure —Fig. 10, page 568. Notwithstanding the heavy piling and timbering serious movements of the ground and threatened collapse of the trench occasioned at times grave anxiety to the engineers and the contractors ; these difficulties were only overcome by leaving in place considerable quantities of the steel piling. The excavation was done chiefly by grabs working from tracks along each side of the trench. The two 5ft. 4in. diameter cast iron sewer pipes laid across the foreshore outside the river embankment are supported on 12in. by 12in. timber piles with walings. These piles were utilised by the contractor to carry part of a temporary works jetty built out into the river at which supplies of aggregates, sand, &c., were unloaded from barges. At the outer end of the permanent piling is a timber dolphin carrying navigation lights.

EXCAVATION OF DOCK SITE.

As soon as the river embankment had been closed and the sewage and storm water diverted into the new pipes the second stage of the construction, consisting of the excavation of the dock and the building of the various structures, was begun. The excavation was done chiefly by dragline excavators and navvies, some steam and some petrol-driven, the excavated material, amounting to over 1,000,000 cubic yards, being used as filling behind the river embankment at the back of the various quays and on the site of the railway sidings. Six steam-driven and seven petrol-driven dragline excavators were employed in the work of excavation. The spoil was loaded into side-tipping wagons and hauled to the several places of deposit. Additional filling was brought from refuse and slag heaps at Scunthorpe to make up the total quantity required for the reclaimed area, which, after consolidation, was covered with colliery refuse to a thickness of 2ft. A view of the excavation in progress, reproduced in Fig. 12, shows clearly the nature

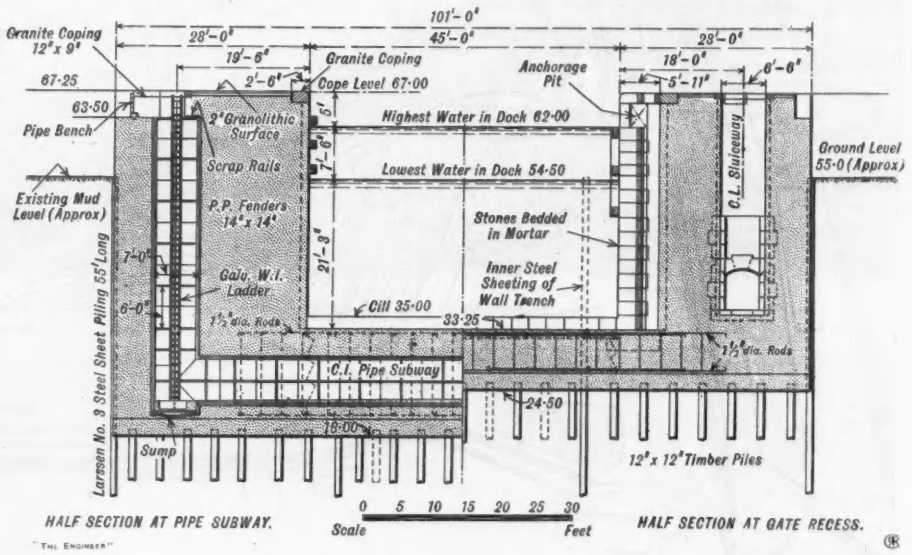


FIG. 8—CROSS SECTIONS OF ENTRANCE LOCK

of the material, which is exceptionally unstable. Over the north-western half of the dock area it was, in fact, nothing more or less than quagmire, and the excavating machines could only be prevented from foundering by working them on large mats formed of 14in. by 14in. timbers, three layers deep, which served as rafts. Even with such precautions the excavating machines escaped overturning on many occasions by only a narrow margin. The site of the dock excavation was kept dry by digging numerous small "grips" and trenches, through which water flowed by gravity to two main sumps, from which it was finally discharged through pipes over the river embankment. The main pumping plant comprised two 14in. and two 12in. electrically driven centrifugal pumps.

LOCK ENTRANCE.

The new lock entrance is 45ft. wide between walls and 204ft. long. A plan of the lock and its approaches and typical cross sections are reproduced in Figs. 8 and 9. The gates are opened about two hours before

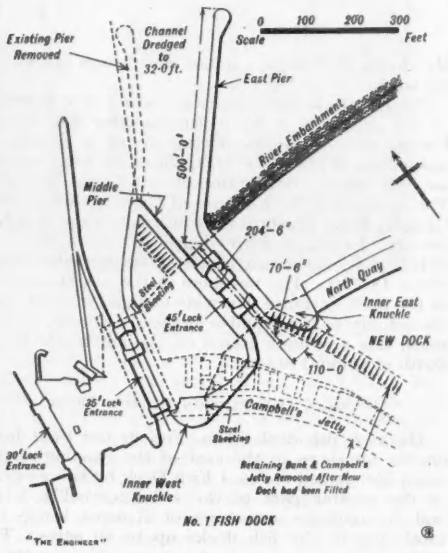


FIG. 9—PLAN OF LOCK ENTRANCE AND APPROACHES

and closed about 1½ hours after high water, trawlers entering and leaving only about high water time. The water level in the dock is never allowed to fall below +54·5ft. or rise above +62·0ft. The outer flood or storm gates are closed to control the dock water level at high tides.

The trial borings made before any of the work on the dock was begun showed that the clay-marl below the overlying soft mud was interbedded with sand, sand and gravel, and peat, occurring in beds at variable depths and of varying thickness, while the

chalk was reached in some only of the boreholes. Particular attention was paid to the strata below the lock entrance, where the excavation had to be taken down to the bottom of the walls and invert, a depth of 30ft. over most of the area and 37ft. at the pipe subway below the foreshore level, before the 12in. by 12in. timber bearing piles could be driven down to the sand and gravel beds. Larssen steel sheet piling in 55ft. lengths was first driven round the area of the lock with an additional line of sheeting on the invert side of each lock wall joining the sheeting across the ends, thus forming complete cofferdams round the site of each wall.

As soon as the river bank had been closed, the excavation in the west wall trench was begun, the work being done by grabs travelling on tracks laid alongside each side of the trench. The timbering was designed to suit the spacing of the bearing piles, which are spaced 5ft. centre to centre longitudinally and 4ft. across the trench. All went well in excavating the west wall trench until the last bay was reached, and was in course of being dug out, when the ground water burst through the overlying stratum of Humber "warp," bringing with it fine sand from the beds below. When this occurred a large part of the concrete work in the west wall trench had already been completed. This had ultimately to be cut out, owing to serious movements in the wall and bearing piles and fracture of the concrete. Owing to the proximity of the work to the existing lock entrances, the "blows" and the consequent run of sand had to be stopped in case these structures should be gradually undermined. A delay of some months occurred during which all work on the lock walls was abandoned while a system of boreholes was put down round the site, and submersible electrically driven centrifugal pumps were installed in filter tubes, so that the level of the ground water over the area could be lowered, the filters being of such fineness that they allowed the water to be pumped without drawing the sand.

The method adopted for lowering the water plane is the same as that used in the construction of the foundations of the new dry dock at Southampton, and was described by Sir Henry Japp in a paper read before the British Section of the Société des Ingénieurs Civils de France, which was published *in extenso* in this journal last year.* Six pump wells and ten observation wells were sunk around the site, some of the wells being taken down to level −30·0ft. By this means the head of artesian water was reduced by some 35ft. (from +53·5ft. to +18·5ft.), and the foundations were completed without further trouble, the pumps being kept running continuously until the invert had been finished.

The timber-bearing piles, which were driven as soon as the trench excavation had been completed, are in lengths up to 40ft. and go down to the sand and gravel beds. Concreting was then proceeded with and the walls built up to ground level (about +55·0ft.), after which the excavation of the invert trench was begun in sections across the lock. The end sheeting of the enclosing dam was supported by diagonal struts butting on the side walls, and struts were placed between the two walls of the lock to prevent forward movement. The levels of the various parts of the floor and sills are shown clearly in the sections (Fig. 8), the lowest part being under the pipe subway, where the foundation is at +18·0ft.

In order to reinforce the invert to withstand the upward hydrostatic pressure to which it would be subjected as soon as pumping had been stopped and the ground water had again risen to the normal level, bands of mild steel bars 1¼in. diameter with ¾in. diameter links, were built into the floor and lapped with similar reinforcement which had already been laid in the side walls, as shown in the section (Fig. 8). Longitudinal reinforcement is also provided connecting the monolithic sections of the invert.

The concrete in the walls and invert is of 1 : 3 : 6 mix, the side walls being faced with 1 : 1½ : 3¼ concrete, 12in. thick. The valve, sluice, and other chambers are also faced with concrete of the richer mix, 6in. to 9in. thick. All sill stones, quoins, and penstock faces are of Cornish granite, and the wall copings of Shap granite.

The three pairs of gates are of English oak with greenheart heel, centre and mitre posts; they are operated by chains and hydraulic rams, emergency hand gear being also provided. The lining of the shafts and subway for hydraulic mains, fresh water mains, and electric cables, is of cast iron segmental rings built into the side walls and invert (Fig. 8).

The construction of the lock entrance involved the use of 560 tons of steel sheet piling, excavation amounting to about 22,000 cubic yards, the placing of 18,400 cubic yards of concrete, and the setting of 18,000 cubic feet of granite.

Outside the lock entrance timber piers have been constructed along the margins of the new entrance channel from the river Humber—see Fig. 9. The pier on the east side is about 500ft. long and that on the west side about 175ft. long; the latter joins up with the old pier leading to the 35ft. lock entrance, the portion of the old structure beyond the junction being removed. Inside the lock timber knuckles have been built on both sides forming a bell-mouthed entrance to assist ships in making the lock.

(To be continued.)

* THE ENGINEER, October 27th and November 3rd, 1933.

University Degrees in Engineering.

No. VI.

(Concluded from page 533, November 30th.)

Manchester University.—In several instances close co-operation will be found to exist between a university and the local technical college. For example at Glasgow an engineering student is permitted to take certain specified courses of instruction at the Royal Technical College in substitution for corresponding courses within the University. At Edinburgh certain classes in the Heriot-Watt College may be recognised, for attendance purposes, as equivalent to University classes. At Belfast a student may take his entire course of instruction at the Municipal College of Technology or partly at the College and partly at the University or wholly at the University. In all these and other similar cases the university retains authority over the examinations and the conferment of degrees. The College may confer associateships or fellowships on its own students but it does not of itself grant university degrees.

At Manchester the position in this respect is different and unique. The University of Manchester consists of Victoria University—formerly Owens College—and the Municipal College of Technology—formerly the Mechanics' Institution. The union took place in 1905 and consisted of establishing the Municipal College as the Faculty of Technology of the University. At Victoria University the Faculty of Science was maintained and within it provision was continued for the training of civil, mechanical and electrical engineers. Courses for such students are still provided and lead to the degree of B.Sc. The higher degrees, M.Sc., Ph.D. and D.Sc., are also open to engineers at Victoria University. At the Municipal College courses are provided for mechanical, electrical, chemical, mining and municipal engineers. These courses lead to the degree of Bachelor of Technical Science—B.Sc. Tech. The higher degrees open to students at the Municipal College are Master of Technical Science—M.Sc. Tech. —and Ph.D. They are also eligible for the D.Sc. degree granted by the Faculty of Science of Victoria University.

In both cases the annual session covers three terms and extends from about the beginning of October to about the first week in July.

At Victoria University the B.Sc. degree course occupies three years but may be extended over four years. During the first year all students take classes in mathematics, physics and certain engineering subjects including laboratory and drawing office work. Metallurgy forms part of the curriculum but chemistry is not included in it. Specialisation between the three branches of engineering begins in the first year as regards the purely engineering subjects of study. At the end of the first year the student takes the intermediate examination. The subjects of this examination are confined to pure and applied mathematics and physics. During the second year the student continues his mathematical and engineering studies and at the end of it takes Part I of the Honours examination which covers pure mathematics and the engineering subjects studied during his first and second years. If he fails in this examination he is transferred to the "ordinary" degree course and at the end of the third year takes the final examination for that degree. If he passes Part I Honours he follows a higher curriculum and takes the Part II Honours examination at the end of the third—or fourth—year. Both "ordinary" and honours degree students are required before taking the final examination to present satisfactory evidence that they can read scientific literature in French or German. The fees for the ordinary and honours courses are 45½ guineas per session except in the case of the third year ordinary degree course for which the fee is 40½ guineas.

The M.Sc. degree is awarded to Bachelors of Science of not less than one year's standing who present a satisfactory thesis.* It may also be awarded to graduates of other universities who conduct research at the University for a period of two years or to non-graduates who spend three years at the University on research work and who, in both cases present a satisfactory thesis. The fee payable on submission of the thesis is 3 guineas and on conferment of the degree 8 guineas.

The Ph.D. degree is open to graduates of Victoria University or any other approved university who pursue a course of advanced study or research in the University for at least two years and who submit a satisfactory thesis or published work embodying the results of their research. Candidates are also required to submit themselves to an oral examination on the subject of their thesis and may also have to take a written examination. Before entering upon his two years' course of advanced study or research a candidate is required to produce evidence that he has been engaged for at least a year previously in research or advanced study. If he cannot comply with this regulation he is required to undertake a year's preliminary training for the Ph.D. degree course. A candidate is not allowed to undertake other work which is likely to interfere with his Ph.D. course or which may restrict the freedom of publication of his results. The fee payable on application to be examined is £10 and on conferment of the degree £5.

* The prospectus of the Faculty of Science does not state that a period of study or research at the University is required in addition to the thesis.

The degree of D.Sc. is open to Masters of Science or Masters of Technical Science of Manchester University four years or more after they have graduated as Bachelors. Holders of the B.Sc. or B.Sc. Tech. degree may after four years be admitted simultaneously to the degrees of M.Sc. or M.Sc. Tech. and of D.Sc. The degree is also open on certain conditions to graduates of other universities and may be conferred on persons deemed by the Senate to have distinguished themselves by special research or learning. Applications for the degree are required to include a statement of the contributions, published or accepted for publication, to science on which the applicant's claim to the degree is based together with copies of any memoir which the applicant may desire to submit in support of his application. The application must be based wholly or in substantial part on original work of merit carried out by the candidate independently. He may in addition submit work done in co-operation with others. A fee of 10 guineas is payable on submission of the thesis and one of 5 guineas on graduation.

At the Municipal College of Technology the course for the B.Sc. Tech. degree extends over three years but may be extended to five years. The degree may be taken either by following an "ordinary" course or a "higher" course. The higher course degree may be awarded with first, second or third-class honours or without honours. The ordinary course degree is awarded in two divisions, an upper and a lower. The degree is therefore obtainable in six classes of merit.

A candidate following the "ordinary" course normally takes the intermediate examination at the end of his first year. The subjects of this examination are mathematics, including mechanics, physics and organic and inorganic chemistry. Mining students may take geology instead of organic chemistry. For the succeeding two years candidates attend courses of instruction in general and specialised subjects and at the end of their third year take an examination consisting of nine papers.

After passing the intermediate examination a student may be recommended by the Board of the Faculty for admission to a higher course. Alternatively if before entering the College he has taken the Higher School Certificate and passed in certain subjects he may be exempted from the intermediate examination and admitted on entering the College to a higher course without delay. In either case the student spends at least three years on a higher course of study in the branch of engineering which he selects. In general the first and second years' higher course curricula are identical respectively with the second and third years' ordinary course curricula. The third year of the higher course is occupied with advanced studies beyond the standard of the ordinary course. The final examination for higher course students is taken in two parts at the end of the second and third years respectively, each part consisting of about six or seven papers.

Both ordinary and higher course students are required to present satisfactory evidence of being able to read their special subject in at least one foreign language. For mechanical and electrical engineers and for chemists the approved language is German and for municipal engineers it is French. Students of mining and of textile technology are required to present a knowledge of both these languages. Courses of language study are included in the ordinary and higher curricula.

The tuition fees for either the ordinary or the higher course degree are £38 16s. 6d. per session for British students and £58 16s. 6d. per session for students from outside the British Isles.

The degree of M.Sc. Tech. may be conferred on graduates of not less than one year's standing who present a thesis consisting of a record, published or not, of original work or of an essay on some scientific question involving criticism or historical research. A candidate may be required to present himself for oral or other examination. The degree is also open to graduates of other universities or to non-graduates who pursue for two or for three years respectively advanced study or research at the College and who submit satisfactory theses. A fee of three guineas is payable on presentation of the thesis and of eight guineas on graduation.

The regulations governing the granting of the Ph.D. degree are identical with those already outlined for Victoria University.

THE UNIVERSITY OF WALES.

The University of Wales—or Prifysgol Cymru, to give it its Welsh title—is in the nature of a central governing body whose activities cover the work of

a number of constituent colleges in the Principality. The University's Registry is situated at Cathays Park, Cardiff. Engineering courses leading to the University's B.Sc. degree are provided at three of the constituent colleges namely at the University College of South Wales and Monmouthshire, Cardiff, at the University College of Swansea and at the University College of North Wales, Bangor. At the third-named college the course provided is confined to the needs of students of electrical engineering. At Cardiff the courses cover civil, mechanical and electrical engineering, mining, metallurgy and fuel technology. At Swansea they cover the three branches of engineering and metallurgy. In addition to the B.Sc. degree the University offers to engineers the degrees of B.Tech., M.Sc., Ph.D., and D.Sc. The D.Litt. degree is also open to suitably qualified graduates.*

The course of study for the B.Sc. degree normally extends over three years for a "pass" degree or over four years for an honours degree. The academic year contains three terms and covers the period from about the beginning of October to the third week in June.

In the case of London University, a comparable example of a non-teaching central governing body controlling the activities of a number of constituent colleges, all the degree examinations are conducted by the University, that is by the central body and not by the constituent colleges or schools. The University of Wales pursues a different plan. So far as engineering students are concerned the effect of the regulations in force is that every candidate for a "pass" B.Sc. degree has to pass a final University examination in civil, mechanical or electrical engineering and two subsidiary examinations one of which is conducted by the University and the other by the constituent college. The college is required to certify to the University that the candidate has attained a standard appropriate to a second year of study in the subject in which it examines him.

Civil engineers normally take geology or metallurgy as their subsidiary, college certificate, subject and pure and applied mathematics as their subsidiary, university examination, subject. The final, university, examination is usually taken in two parts, at the end of the second and third year respectively. The first part covers the theory of machines, heat engines and hydraulics and the second part, the strength of materials, the theory and design of structures and surveying. The subsidiary subjects taken by mechanical engineers are metallurgy (college certificate) and mathematics (university examination) and the final subjects the theory and design of structures and hydraulics in the first part and the strength of materials, heat engines and the theory and design of machines in the second part. Electrical engineers take physics (college certificate) and mathematics (university examination) as their subsidiary subjects and, for their final examination, the strength of materials and the theory of machines in the first part and electrical technology, the theory and design of electrical machines and heat engines in the second part. These syllabuses apply particularly to the University College of South Wales, Cardiff. At the University College of Swansea the syllabuses are not quite the same, the most notable difference being the inclusion of electrical technology in the final examination subjects for all three branches.

For an honours degree a candidate must study as for a pass degree and in addition take, and be examined in, mathematics and two engineering subjects on an honours standard. A limit of five years is placed upon the period of study required for an honours degree. No candidate is permitted to present himself for a second time at an honours examination but a candidate who fails to obtain honours may be awarded a pass degree. The tuition fee for the B.Sc. degree course is £20 per annum.

The degree of B.Tech.—*Baccalaureus in Technologia*—is confined to students of *mechanical* engineering or industrial chemistry. Mechanical engineering candidates for this degree are required to pursue a course in mathematics, physics, chemistry and engineering for at least a year at a recognised technological institution. Thereafter for at least two years they are required to take at a constituent college of the University courses in metallurgy, pure and applied mathematics, the theory of structures, hydraulics, the strength of materials, heat engines and the theory and design of machines.

The M.Sc. degree is awarded for research in some branch of mathematics, pure or applied science or moral science. It is open to holders of the B.Sc. degree with honours one year after graduating and to holders of the pass degree two years after graduation. Graduates of the University of Wales are *not* required to pursue their scheme of research in one of the constituent colleges. Graduates of other universities who may be candidates for the degree are required to spend at least two years on their scheme of research at one of the constituent colleges. The methods and results of the research have to be submitted for the approval of appointed examiners who also examine the candidate orally and, if required, in writing. A fee of £8 is payable on submission of the dissertation.

Candidates for the Ph.D. degree are required to be graduates of at least three years' standing either of the University of Wales or of some other approved university. The qualification for the degree is the pursuit for at least two years of an approved scheme of research at one of the constituent colleges. In general candidates for the degree will not be approved as qualified to enter upon their proposed scheme of research unless they hold a Master's degree obtained by research or advanced study or have had research experience after graduating comparable with that required for the Master's degree. The results of the research must be embodied in a work which, in the opinion of the examiners, is worthy of publication by the University. An oral and, possibly, a written examination may be imposed on the candidate. The fee payable on the submission of the report is £12. The regulations expressly debar the degree of Ph.D. being conferred *honoris causa*.

The degree of D.Sc. is open to holders of the Ph.D. degree of the University two years after qualifying for that degree and to holders of the M.Sc. and B.Sc. degrees three years and ten years respectively after qualifying. A candidate for the degree is required to submit to the judgment of the University "contributions to the advancement of knowledge in some branch or branches of the mathematical, pure, applied or moral sciences." In the case of graduates whose contributions to the advancement of knowledge have been made in philosophy, economics, political science or education the Vice-Chancellor may decide that the degree to be awarded shall be the D.Litt. The fee payable for admission to candidature for the degree is £20.

Under previous headings some mention has been made of the difficulty of discriminating between the qualifications for the D.Sc. degree and those for the D.Litt. degree. In the above paragraph it might appear that a more or less precise definition is embodied so far at least as the University of Wales is concerned. Actually the regulation as to the Vice-Chancellor's discretion does little or nothing to clarify the point. Turning to the regulations governing the degree of D.Litt. we find it stated that in the case of graduates whose contributions to the advancement of knowledge have been in philosophy, economics, political science, education, pure mathematics or applied mathematics the Vice-Chancellor may decide that the degree to be awarded shall be the D.Sc.

The Irish Universities.

Belfast University.—At the Queen's University of Belfast the degrees which engineers may take are B.Sc., M.Sc., Ph.D. and D.Sc.

The B.Sc. course normally covers three years each containing three terms and extending from about the beginning of October to the middle of July. The degree may alternatively be obtained after five years' attendance at evening classes at the Municipal College of Technology provided the student obtains by concurrent day-time employment satisfactory industrial experience in the subject of his studies. The B.Sc. degree may be obtained in civil, mechanical or electrical engineering, naval architecture, chemical technology, industrial science and other branches. It may be noted that civil engineering is taught in the Faculty of Science while all the other branches are taught in the Faculty of Applied Science and Technology. There are three examinations, the intermediate, the final, part I, and the final, part II. For the degree in civil engineering the subjects of the first examination are mathematics, mathematical physics, experimental physics, chemistry, drawing, and general engineering. First-year students are also required to take a course of engineering workshop practice. They are not subjected to an examination in this subject but their class-marks obtained in it during the session are included with the intermediate examination results. For the final examination part I civil engineers are examined in mathematics, mathematical physics, strength of materials, theory of structures, surveying and electrical engineering. Attendance at a surveying camp is required as part of the curriculum. The final examination part II covers economic geology, strength of materials, theory of structures, hydraulics and waterworks, surveying of railways and roads, design and practical surveying. Honours are awarded on the results of the final examination, no special papers being set. The syllabus of subjects for the intermediate examination in the other branches is the same as in civil engineering. For part I of the final examination mathematics and experimental physics are common to all the branches. In addition mechanical and electrical engineers take similar papers in mechanical and electrical technology. For the final part II examination mechanical engineers are examined solely in subjects of mechanical technology such as prime movers, strength of materials and mechanical laboratory work while electrical engineers are examined solely in subjects of electrical technology such as generation and distribution of electricity, electric traction and electrical testing. For naval architects and students in the other branches the subjects of the final examinations are partly or wholly specialised. The inclusive fee for the B.Sc. degree course in any branch is 63 guineas. In addition to matriculated students of the University who attend the prescribed courses and pass the prescribed examinations the degree of B.Sc. may be conferred upon graduates of other Universities whom the Senate may decide to admit *ad eundem gradum*.

The degree of Master of Science, M.Sc., may be conferred on Bachelors of Science of at least one year's standing. It is conferred either on submission of a thesis or in recognition of independent research. A thesis produced in collaboration may be accepted for the degree. To obtain the degree by means of a thesis candidates are required to spend at least two years at the University on higher study or research or one year if they hold an Honours degree. Graduates of other universities are eligible for the degree. A fee of 3 guineas is chargeable on application for the degree and one of 5 guineas on admission to it.

The degree of Ph.D. may be conferred on graduates who pursue a course of study or research at the University extending over at least two years, and who submit satisfactory theses embodying the results of their work. If not already published the thesis must be in a form suitable for publication. The candidate's work is supervised by the staff. A fee of 5 guineas is payable on application for the degree and a like sum on admission to it.

The degree of D.Sc. is open to graduates of at least three years' standing. It may be obtained by the submission of a thesis recording the results of research or other work in relation to pure or applied science done by the candidate. It may also be conferred by the Senate, on the recommendation of the Academic Council, upon graduates of the University who are distinguished in science, engineering or other practical application of science. The fee for the degree is 6 guineas on application and the same amount on admission.

Dublin University.—Trinity College, Dublin, has the distinction of possessing the second oldest school of engineering at any university in Great Britain and Ireland. The school was founded in 1842, two years after Queen Victoria established a Chair of Engineering at Glasgow University.

The prospective student has to pass the University's matriculation examination, or its equivalent, and subsequently gains admission to the engineering school by passing an additional entrance examination in elementary mathematics and mechanics. The academic year covers three terms and extends from about the beginning of October to about the first week in July. In the engineering school the course provided embraces three years with an optional fourth year for students desiring to undertake specialised advanced studies in one of the three main branches of engineering. On satisfactorily completing the course and passing the prescribed examinations the student is entitled to receive a "certificate in engineering" issued by the professors of the engineering school. If, in addition, he completes satisfactorily the first two years of the course for the ordinary B.A.—Bachelor in Arts—degree he is entitled to receive a "licence in engineering" granted by the University. If he not only completes his course in the engineering school but graduates in Arts he becomes entitled to the degree of B.A.I. *i.e. Baccalaureus in Arte Ingeniaria* or Bachelor in Engineering.

To obtain the engineering degree of B.A.I., therefore, the student must also obtain the ordinary B.A. degree. The normal course for the ordinary B.A. degree covers three or four years and involves the passing of two main examinations, the final freshman—or "Little-Go"—examination taken at the end of the second year and the degree examination taken at the end of the course of study. The subjects of study for the degree are Latin, a foreign language, English composition, mathematics, logic, physics and chemistry or some combination of these subjects. An engineering student is not, however, required to take the full B.A. course separately from his engineering studies. As a student of engineering he obtains certain "professional" privileges which enable him to count as part of the work for the B.A. degree some of the work which he does in the engineering school. To obtain the B.A. degree it is sufficient for him to keep, in all, six terms in Arts and to pass the two main examinations. The subjects, outside those pertaining to the engineering school, which he is required to study and in which he is required to pass are languages, logic and English composition or some combination thereof.†

During the first year of his professional course in the engineering school the student attends lectures and laboratory or field classes in mathematics, mechanics, physics, chemistry, geology, surveying and drawing. During the second year he continues his studies in these subjects and in addition studies the design of structures and attends lectures on

* It may be noted here that the abbreviations B.Sc., M.Sc. &c. are abbreviations not of English but of Latin words. Thus B.Sc., speaking with strict academic accuracy, means *Baccalaureus in Scientia*, M.Sc. stands for *Magister in Scientia*, Ph.D. represents *Philosophiae Doctor* and D.Sc. is to be interpreted as *Doctor in Scientia*. That the titles are really Latin titles is revealed by the fact that the contractions for the degrees commonly spoken of as Doctor of Letters and Bachelor of Surgery are D.Litt. and B.Ch. respectively, meaning *Doctor in Litteris* and *Baccalaureus in Chirurgia*. A curious case is provided by the degree of B.A.I. given by Trinity College, Dublin. We have heard these letters interpreted as "Bachelor of Arts and Industry" and in other ways. Actually they mean *Baccalaureus in Arte Ingeniaria*, that is, Bachelor in Engineering. The University of Wales adheres to the Latin titles of its degrees with exceptional consistency.

† The regulations issued by Trinity College, Dublin, are so involved and difficult to understand that we have considerable hesitation in claiming that we have correctly interpreted them at all points.

mechanical and electrical engineering. In the third year his studies are enlarged to include such subjects as roads, railways, harbours, docks, hydraulics, waterworks and sewerage. If he desires to become a mechanical or electrical engineer he may be allowed to substitute suitable alternatives for some of these civil engineering subjects. In the optional fourth year the student may devote himself to specialised advanced studies in civil, mechanical or electrical engineering according to the branch which he desires to follow. An arrangement exists whereby a student is permitted to reckon half the number of hours spent on his Arts course lectures as having been spent in the drawing department of the engineering school and as counting towards the attendance required of him in that department. The B.A.I. degree may be awarded with honours on the strength of the student's performance in his examinations. The total fees for the B.A.I. course including the B.A. course amount to £151.

The degree of M.A.I., that is, Master in Engineering, is open to a holder of the B.A.I. degree who produces satisfactory evidence that he has been engaged for a period of at least three years on the design or construction of important engineering work or on engineering research.

The Ph.D. degree is granted to graduates of Dublin or other university who pursue at the University for six terms an approved course of advanced study or research under the supervision of the Professor concerned with the subject of the research. A thesis showing evidence of independent inquiry and of originality either in conclusions or in method is required and if thought necessary the candidate may be subjected to an oral or written examination.

The degree of Doctor in Science, Sc.D., is open to a holder of the University's B.A.—and therefore of the B.A.I.—degree, of not less than three years' standing. The primary test for the doctorate is original published work containing results marking an advance in scientific knowledge. A fee of £10 is payable to the examiners appointed to inquire into the applicant's claims to the degree. The regulations governing the degree of Doctor in Letters—Litt.D.—are similar except in so far that the published work must form an original contribution to the study of literature, philosophy, æsthetics, history or archæology.

Trinity College in addition to the degrees mentioned above also awards the degrees of B.Sc., M.Sc. and Sc.B. (Tech.) that is Bachelor and Master in Science and Bachelor in Applied Science. The B.Sc. degree is not an engineering degree and is confined to students taking courses in physics, chemistry, botany, geology, zoology, physiology and anatomy or a combination thereof. The M.Sc. degree is open to graduates of distinction in Arts—and therefore to holders of the B.A.I. degree—and to graduates with honours in science following at least one year of advanced study and research at the University. The regulations governing the granting of the degree of Sc.B. (Tech.) are not known to us except in so far that candidates for this degree must be Bachelors in Arts of the University.

Bus-Bars for Outdoor Sub-Stations.

No. I.

By A. M SPRUCE, A.A.I.E.E.

General.

IT is intended in these articles to outline as far as possible the factors which govern the sag and tension of strained bus-bars erected in outdoor sub-stations. The electrical considerations are also included, and information given regarding materials and material properties to enable an economical choice to be made for these connections.

In outdoor stations the main interconnections are made with solid rods or tubes supported on post insulators, forming a continuous beam over several spans, or with flexible cables strained between two structural supports and insulated from them with cap and pin type insulators. With the latter, the general appearance of the station will depend to a large extent upon the correct mechanical design, as well as the method of supporting and the frequency of supports over the complete span. By "mechanical design" it is intended to convey the effect of conductor strain on the sag, and the weight of the supporting structure necessitated by this strain. In addition, the electrical characteristics of the bus-bars must be given careful consideration as regards current-carrying capacity, the conductor diameter and surface conditions to prevent corona at high voltages, and the material conductivity.

In sub-station work the prevention of corona on the conductor surfaces is not alone desirable from the losses which result, but still more from the point of view of the breakdown of apparatus insulation, which, in time, would occur under the continued bombardment of ionised streamers. Not only is corona formation affected by the conductor diameter and surface conditions, but also by the spacing of the conductors, the density of the air, and the weather conditions (fair or stormy). The presence of corona is manifested by a hissing sound, and the phenomenon is visible at night in the form of a purplish glow round the conductors. Its creation is greatly facilitated in damp salt-laden atmospheres, and it is not uncommon for stations situated near the sea coast to be well illuminated on a wet night by corona discharge. Peek's formula[1] for the critical disruptive voltage of conductors is well known and need not be mentioned here.

Bus-bar Insulation and Sag Calculations.

The general formulæ for the sag and tension of conductors erected on small spans usually follow those employed in transmission line engineering, with this difference that as the spans are much smaller the end insulators will slightly increase the sag, and the necessary allowance should consequently be made in the calculations. The sag is probably most easily approximated by treating the bus-bar as a uniform conductor supported at two points, and finally adding a factor depending upon the number of strain insulators used.

Sag and tension formulæ in which the insulator weights are directly incorporated may also be derived, but they are rather complicated and lengthy in their solution.

The bus-bar insulation, in addition to varying with the operating voltage, should be co-ordinated with the insulation of other parts of the high-voltage system. It varies greatly with local conditions, and is also influenced by considerations of switching surges, and lightning. As a rough guide to the number of strain insulators required for various station voltages in use at the present time, reference should be made to the following table :—

TABLE I.

Operating voltage. kV.	Strain insulators.
22	2–3
33	3–4
44	4–5
66	5–7
88	6–8
110	8–10
132	10–12
154	12–14
220	16–19

An indication of the sag that is likely to occur in a strained bus-bar is necessary in order to allow for the correct electrical clearances between conductors or conductors and earth in the initial design of the station. Also curves must be supplied to the erection department giving the sag and tension over the complete working temperature range. From these curves the erector is able to string the bus-bars to the correct tension at any particular temperature, so that under the worst conditions of loading the tension will not exceed a known maximum.

Limiting Tension in Strained Bus-bars.

In deciding upon the maximum tension that should be imposed on a bus-bar, the governing factor is usually the type and height of the supporting structure, rather than the sag which the centre of the conductor will take. The cost of sub-station structures depends upon the quantity of material used in their construction, and to keep weight to a minimum (neglecting supported apparatus), the external bus-bar forces must be kept as low as possible.

A common type of support is a cantilever structure with the electrical connections anchored at the top. These structures may either be of the compound or single member type, with one or more supporting columns, and since the bending moment varies directly as the height, with large bus-bar tensions a large structure modulus is required. Moreover, large conductor sags are likely to give the station an ugly appearance, particularly if they are of greatly varying amounts on the different spans used. The tensions, therefore, must be chosen so that the supporting structure is economical consistent with a reasonable sag. This, in fact, is a point in favour of tubular connections which only form a vertical dead load and do not impose large side forces on the structure.

Strained Bus-bar Tensions.

Sub-station connections in tension usually need not be strained to give a factor of safety of 2, as is customary with transmission line conductors. For large cross-sectional areas this would result in unreasonable tensions, so that except for very small sections, factors of safety varying from 3 to 6 are more economical. The saving effected in the height of the supporting structure using a conductor factor of safety of 2 (thus giving a small sag), is not in proportion to the increase in structure weight due to the increased tension. This is illustrated in Fig. 1 by a set of curves which give the variation of the sag with span length for various conductor tensions at 122 deg. Fah. It is evident that for a large increase in the tension the decrease in sag is relatively small, and would not justify the extra supporting structure weight.

For cables of medium cross-sectional area a figure of approximately 2000 lb. will usually meet the requirements. When station voltages are of the order of 220,000, the diameter of the cable (but not necessarily the area) must be fairly large to minimise corona. Stations operating at such high voltages will generally have large spans, and with the large number of cap and pin insulators necessary to insulate the buses, the maximum working tension may have to be increased to 2500 lb. or 3000 lb.

As a general rule, the higher the voltage the more economical it becomes to use strained bus-bars instead of the tubular or rigid type. This follows from the fact that the large spans obtained on high-voltage

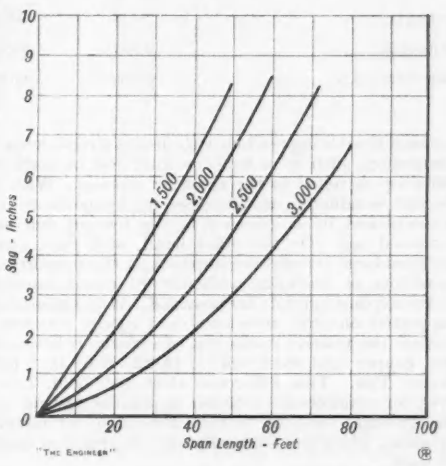


FIG. 1

stations necessitate large-diameter tubes to keep their deflection within safe limits. Below about 66 kV rigid connections often lead to cheaper structures, since they do not impose large forces on the supports. Although theoretically it is not possible to give any definite limiting voltage at which rigid and strained bus-bars can be used, in practice it is often found that a combination of the two gives the desired economy and station flexibility.

Bus-bar Materials.

The choice of conductor materials for strained buses lies between copper, aluminium, and steel-cored aluminium. Many of the problems confronting the transmission line designer, necessitating the use of strong yet light conductors, do not enter into sub-station design. Strong conductors are not required, but rather those which have high conductivity and permit easy jointing of branch connections on site. Owing to the large number of taps required from conductors to apparatus, it is found that copper is more suitable than any other material, even though the outgoing line may be of aluminium. A further point in favour of copper is that it is relatively cheap and has a high salvage or scrap value. In comparison with copper and for equal conductivity, aluminium wire has approximately 70 per cent. of the strength, 50 per cent. of the weight, and 166 per cent. of the volume.

Electrical Connections Between Dissimilar Metals.

When making connections between copper and aluminium it must be borne in mind that as dissimilar metals are in contact and situated out of doors, electrolytic action will be set up if moisture is present. The elements aluminium and copper are widely separated in the electro-chemical series, the former being anodic to the latter. Consequently, in acid fume atmospheres the aluminium is rapidly sacrificed, the joint soon deteriorates, and commences to heat up.

Various methods are employed to avoid electrolytic action. About the most satisfactory is one in which an internally screwed connection is made between the aluminium and copper (or other non-ferrous metal) tap. In the joint between the two metals an insulating washer is tightly clamped so that circulating currents are avoided. The contact surface between the dissimilar metals is therefore totally enclosed, and the ingress of moisture prevented by the insulating washer.

Painting the complete joint with pitch or heavy commercial petroleum has been resorted to at times, but periodic inspection is necessary to ensure that the joint is always completely covered. Another method, and one which has been used considerably in America in the past, is to sweat an aluminium liner into a copper alloy main body, or alternatively, a copper liner into an aluminium body. In addition, pro-

[1] See bibliography.

tection of the end surfaces of the metal insertion and main body is necessary where they are exposed to the atmosphere, and is effected by painting.

Tap connections of the internally screwed type are very suitable for taking a copper connection from an aluminium run, or joining the free end loop of the anchored aluminium line directly into the apparatus terminals. In the latter case provision may be made for securing the outer aluminium wires and internal steel wires separately between cone grips.

Physical Properties of Materials.

The physical properties of copper and aluminium as given in Table II are used in the determination of bus-bar sags. The figures are standard for Great Britain, but in certain instances will be found to differ from those used in the United States.

When comparing the effect of expansion of a strained flexible copper bus with that of a rigid copper connection, such as a tube or solid rod, a marked difference is noted in the resulting stresses. With a flexible conductor an increase in temperature is accompanied by a decrease in the tension and an increased sag. On the other hand, with rigid connections large stresses are imposed on the supporting insulators or bushings, sufficient to cause damage unless expansion joints are provided. With apparatus supported on steel structures and rigidly interconnected, the relative coefficient of expansion between the copper and steel will be $(9{\cdot}22-6{\cdot}6)\ 10^{-6}$ per degree Fah. This difference does not hold, however, for connections between apparatus resting on the ground, such as transformers and oil circuit breakers, where the full coefficient of expansion must be used.

The modulus of elasticity and coefficients of expansion for steel-cored aluminium cables, which are of the composite type, are not included in Table II, as these properties depend upon the ratio of aluminium to steel sections, but are readily calculated as follows :—

$$c=\frac{12{\cdot}6\,R+20}{R+3{\cdot}13}\times 10^{-6} \text{ per deg. Fah.}$$

where c = the coefficient of linear expansion per deg. Fah.

and R = the ratio of aluminium section to steel section.

$$E=\frac{9{\cdot}6\,R+30}{R+1}\times 10^{6} \text{ lb. per square inch.}$$

The values of c and E for composite cables are termed "virtual" values. Complete tables giving the stranding and properties of aluminium and A.C.S.R. cables have been published by the British Aluminium Company.[2]

Table II.—*Physical Properties of Bare Cable Material.*

Material.	Weight in lb. per sq. in.	Modulus of elasticity E, lb. per sq. in.	Ultimate strength, lb. per sq. in.	Elastic limit, lb. per sq. in.	Coefficient of linear expansion, per deg. Fah.
Copper H.D.	0·318	18×10^{-6}	60,000	33,000	$9{\cdot}22\times10^{-6}$
Aluminium	0·0977	$9{\cdot}6\times10^{-6}$	24,000	15,000	$12{\cdot}6\times10^{-6}$
Steel (in A.C.S.R.)	0·283	$30{\cdot}0\times10^{-6}$	180,000	130,000	$6{\cdot}4\times10^{-6}$

Hard Drawn Copper Conductors: Properties and Current Rating.

On low and medium voltage systems strained bus-bars are usually formed of solid stranded copper conductors. For this purpose standard cross-sectional areas to carry any value of current for a certain temperature rise are easily obtained. A list of the most common sizes for outdoor sub-station work, varying from 0·06 to 0·30 square inches in area, is given in Table III. Other properties necessary for the calculation of sags are also included, such as breaking load, weight per 1000ft., and overall diameter. These properties are for hard drawn copper conductors, and are based on B.S. specification No. 125. Cross-sectional areas less than 0·06 square inches are seldom used, and areas larger than 0·30 square inches may be obtained from the B.S.S. quoted, or from the "Cable Research Handbook," Vol. II[3], which contains comprehensive tables of bare conductor properties.

The size of conductors for station bus-bars will be governed rather by the maximum allowable temperature rise and corona value than by the voltage drop. The current ratings given in the last two columns of Table III are for a 30 deg. Cent. rise above a 40 deg. Cent. ambient at 50 cycles. These capacities have been computed from tests[4 and 5] made in Schenectady on American gauge wire.

For outdoor current rating the conductors are supposed to be in a partly sheltered location and subject to the very low wind velocity of 1·36 m.p.h. (2ft. per second) normal to the conductors. The wind velocity is usually greater than 2ft. per second, unless the location is very sheltered. But if the general wind conditions are known for the locality in which the station is to be erected, taking into consideration altitude or the sheltering effect of adjacent buildings and hills, &c., an approximate current rating may be assigned to the conductors.

The current values for conductors situated indoors are also included in the table for comparison with the outdoor values. The indoor conductors are assumed to be in a horizontal position in still air, and as the heat is dissipated only by radiation and free convection, the current ratings will be much lower than for outdoor situations.

Although the factor of safety of strained bus-bars is usually high, the mechanical properties of the cable must not be affected by excessive heating, which would happen were it allowed to reach 100 deg. Cent. Hard drawn copper wire begins to soften at this temperature, and oxidises at about 80 deg. Cent. This latter figure, therefore, must be taken for the maximum operating temperature of the bus-bars, no matter in what country they are situated.

The general standard temperature rise is 30 deg. Cent. above an ambient of 40 deg. Cent., giving a final operating temperature of 70 deg. Cent. In countries where the ambient air temperature differs from 40 deg. Cent., either above or below, the current rating of the conductors should be varied accordingly. In Central and Eastern Europe the air temperature reaches 50 deg. Cent. in many places, whilst more northerly countries will have maximum ambients of 30 deg. Cent. In the tropics it is not unusual for conductor temperatures to reach 80 deg. Cent. by sun heat, so that in such cases the conductors must be very liberally rated and a large cooling surface provided.

(To be continued.)

Table III.—*Current Rating and Properties of Standard Bare Hard Drawn Copper Conductors.*

Nominal area, square inches.	Strand.	Breaking load of conductor, lb.	Standard weight per 1000ft., lb.	Overall diameter, in.	Current rating in ampères, 30° C. rise, 40° C. ambient.	
					Outdoor, 1·36 m.p.h. wind.	Indoor, still air.
0·06	19/·064	3,642	240·0	0·320	200	152
0·075	19/·072	4,586	303·9	0·360	233	176
0·10	19/·083	6,072	403·7	0·415	285	211
0·12	37/·064	7,076	468·0	0·448	316	235
0·15	37/·072	8,930	592·0	0·504	367	275
0·20	37/·083	11,822	787·0	0·581	440	336
0·25	37/·093	14,750	988·0	0·651	504	390
0·30	37/·103	18,030	1,212·0	0·721	570	449

The Quality of Steel and Magnetic Research *

By T. F. WALL, D.Sc., D.Eng.

During recent years much research has been carried out by numerous investigators with a view to devising some simple, reliable, and practical test which will make possible the observation of the gradual work-hardening of the wire of winding ropes and, ultimately, the provision of a scale of measurement of its actual progress. So far as is known, the only methods which have yielded results that show in a practicable and unmistakable fashion the onset of work-hardening are the magnetic methods now being developed in the Electrical Engineering Department of Sheffield University.

Magnetic Tests for Work-hardening.

Two distinct magnetic methods have been devised, each of which has its own special field of application. One of these methods comprises a ballistic test, the essential feature of which is the observation of the increase of magnetic permeability when a wire is loaded after it has been placed in a magnetic field of suitable strength. This method is, in fact, an examination of the combined effect of the application in the proper sequence of a mechanical force and a magnetic force.

Since magnetic phenomena are fundamentally molecular or atomic effects and since magnetic effects may now be measured with a high degree of accuracy, it is reasonable to expect that any change in the atomic or molecular structure of the material of a steel wire due to work-hardening should be most easily detected by magnetic means. Repeated attempts to obtain the desired results from the ordinary tests for permeability have, however, proved to be of no avail, and it is only when a mechanical and a magnetic force are applied in the correct sequence and are simultaneously operative that the ballistic test reveals the effects of work-hardening in a striking manner.

That a steel wire contracts when placed in a magnetic field of moderate strength was observed by Joule many years ago. A demonstration of this effect is easily made by suddenly impressing a magnetic field of suitable strength on a steel wire, when a definite click, due to the sudden contraction of the wire, can be heard. On the other hand, when an iron or steel wire is magnetised to a moderate degree and is then stretched by a load the magnetisation will be increased as the result of the stretching. This interaction of magnetic force and mechanical strain is usually known as the "magneto-striction effect" and recent work has shown that the intensive experimental investigation of these phenomena is likely to prove a most fruitful line of electrical engineering research.

The ballistic magneto-striction test may be applied most easily to short pieces of wire, such, for example, as may be taken from the length of wire winding rope which is cut off for the periodic capping process.

Travel of a Pulse of Stress.

The second type of magnetic test which has been developed for the purpose of observing and measuring the degree of work-hardening which a wire has received is especially appropriate for lengths of wire which are greater than about 100ft. In essence, this test consists in starting a pulse of stress at one end of the wire and observing by electro-magnetic means the rate at which the pulse travels along the wire and also the rate at which it decays as it travels. The rate of travel of the pulse is a measure of the value of Young's modulus and this quantity is of itself an indication of the state of work-hardening. Moreover, this method of measuring the value of Young's modulus is, as far as the writer is aware, the only one which is applicable to the case of a twisted and deformed wire, such as those which have formed part of a wire rope. The rate at which the strength of the pulse decays as it travels along the wire is a measure of the effective viscosity of the wire, and it is this observation which provides such a striking demonstration of the degree of work-hardening. A full technical account of these investigations, together with examples of photographic records of the decay of the pulse of stress as it passes along the wire at the speed of sound will be published in due course.

In what has been said already reference has been confined to the application of these new magnetic tests to the examination of work-hardening in steel and iron wires. This application, however, is not the only practical use of the tests. An example of another application is the examination of the effects of heat treatment on wires and actual test data show that the tests provide means for observations of this kind from an entirely new angle.

Testing of Welded Joints.

With the rapid development of new structural processes new problems present themselves which often may be most satisfactorily solved by the use of electro-magnetic methods. A notable example of this is to be found in connection with electric welding. In the last few years electric welding processes have made very rapid strides. Electric welding is displacing riveting and electrically welded structural work is taking the place of castings to a very great extent, the costs of production having been notably reduced by these means. A further important example of the significance of electric welding is to be found in the large-scale production of steel tubes of all diameters in which the seam of the tube is electrically welded. The quality of such welded joints and seams may be most satisfactorily tested by electro-magnetic means and at least one type of an apparatus for this purpose is now available as a commercial article.

Increasing Hardness by Magnetisation.

A fascinating line of research which has led to astonishing results is the discovery that the quality of steel may actually be improved by the application of a suitable magnetic field. A successful investigator in this work is E. G. Herbert, who has given an account of some of his experiments in the "Proceedings" of the Royal Society (Series "A," Vol. 130 : 1930–1931), in which the following results are disclosed. A specimen of high-speed steel was quenched in oil from 1300 deg. Cent. Hardness measurements were made immediately after quenching and thereafter at half-hourly intervals, and stability was attained after the lapse of two hours, the Brinell hardness figure then being about 750. Magnetic treatment consisting of 100 slow revolutions in a magnetic field of 14,500 units was then applied. The result of the magnetic treatment was an immediate decrease in the hardness figure to about 700, followed by an increase to a stable value of about 820 in three hours.

The practical application of this result is of high importance, since finished tools, whether of a simple or a complicated character, such as drills, saw blades, milling cutters, dies, or other articles of steel, in which a high degree of hardness is beneficial, may be treated in this manner without in any way interfering with the finish.

An even more surprising result is the effect of magnetic treatment on the hardness of non-magnetic materials, such as duralumin and brass, notable increases of hardness being obtained in each of these metals. With regard to duralumin, however, the reality of the effect has been disputed by later investigators.

Magnetic Research and New Alloys.

No line of electrical engineering research is of greater interest than the investigation of magnetic phenomena, and none is more likely to lead to results of outstanding importance from the purely scientific as well as the practical standpoint. As the result of specialised research in this field of inquiry, there exist to-day a number of materials having magnetic characteristics of a peculiar nature, the discovery of which has led to commercial results of great financial value. Reference will be made to two of these special alloys.

Many years ago Sir Robert Hadfield discovered the alloyed steel known as "stalloy," in which a small per-

* From *Quality*, Journal of the Sheffield Chamber of Commerce.

centage of silicon is an essential constituent. This material is made in thin sheet form and is of high magnetic quality. Its outstanding characteristic, however, is that, notwithstanding its high magnetic quality, it also has a high electrical resistivity—about four times that of commercially pure iron. The effect of this high electrical resistance is that when transformer cores are built up of this material the energy losses produced by the alternating magnetic fields in these cores are very greatly reduced. It was estimated some years ago that in respect of the transformers in operation in America alone the annual financial saving which this reduction of energy loss represents is of the order of several million pounds sterling.

Another example of the discovery of a special alloy having remarkable magnetic characteristics is the material known as "permalloy," which is an alloy of iron and nickel in particular proportions. This was discovered in the research laboratories of the Western Electric Company in America and the property which gives it its value is the remarkably high value of the permeability for small values of the magnetising force. Permeabilities of the order of 100,000 are obtainable with this material, whereas 5000 is a high value for the permeability of commercially pure iron. The production of "permalloy" has revolutionised the submarine cable industry, since it is exactly the kind of material which is required for "loading" telephone cables to prevent speech distortion.

SOME UNSOLVED MAGNETIC PROBLEMS.

A prominent authority in the United States has expressed the view that if an alloy could be produced which, for those values of the magnetising force usual in heavy-current practice, would exhibit such high values of permeability as "permalloy" exhibits for feeble magnetising forces, the discovery would rank as one of the major developments in the history of electrical engineering.

Another problem which is of the greatest interest is the "recalescence" of iron. It has been known for 300 years that when iron is heated to redness it becomes non-magnetic. Fifty years ago Professor Barrett discovered the fact that when iron is heated to bright redness and then allowed to cool down to a deep red colour, it suddenly glows up again as though heat energy had been released within the iron itself. To this sudden brightening the name of recalescence has been given. A full explanation of what happens to cause simultaneously the sudden change of the iron from a non-magnetic state to a magnetic state and the release of a relatively large amount of heat energy would be of a value the importance of which it would be difficult to over-estimate.

Another remarkable line of investigation is suggested by some results which were recorded by Professor J. C. M'Lennan, F.R.S., in his Kelvin Lecture delivered before the Institution of Electrical Engineers on April 26th last. He found that if a highly paramagnetic salt was cooled down to the temperature of liquid helium in a magnetic field and the field was then reduced from an intensity of 30,000 to 1000 units, there was an immediate lowering of temperature. Professor M'Lennan concludes that this result suggests great possibilities for the production of low temperatures. The question that arises from these experimental results may be stated thus: What changes taking place in the structure of the material when the intensity of the magnetic field is reduced can account for the absorption of a large amount of heat energy?

As a further problem of fundamental importance may be mentioned the well-known Heusler alloys. These alloys are composed of manganese, aluminium, and copper, each of these metals being non-magnetic. The alloy, however, is strongly magnetic and has a permeability of the same order as nickel. In this connection it is of interest to note that aluminium is a constituent of the new Japanese (M.K.) magnet steel for which it is claimed that values of the coercive force as high as 650 units have been obtained.

Wear Testing Machine.

IN general it may be said that the resistance to wear of metallic articles does not depend only on the strength of the material nor only on its hardness. Hardness indicates durability against wear only if materials having the same composition and heat treatment are compared. It is, however, impossible to judge—according to the value of hardness of substantially different materials—what relative ability to resist wear they have. In such cases the materials should be individually tested for resistance to wear. In the Skoda-Sawin machine, marketed in this country by the Selson Machine Tool Company, Ltd., of 23, Abbey House, Victoria-street, London, the wear is tested by means of a standard rotating disc of Widia. It offers the possibility of quickly testing the surface in less than five minutes and expressing the resistance against

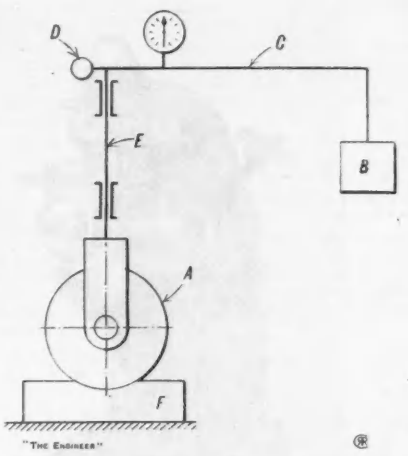


FIG. 1

wear with a sufficient measure of probability in units of volume of the impression in thousandths of a cubic millimetre, which has been attained after a specified number of revolutions of the disc. The disc works at a specified load and circumferential speed. The impression caused by the disc does not, it is claimed, damage the surface of the tested article and the test itself can be carried out in the workshops in a similar way to that of carrying out tests of hardness on the Brinell, Rockwell, and Vickers apparatus.

The principle of the machine is shown in Fig. 1; the disc A is supported on two bearings, connected by a yoke. The weight B acts on this yoke through a lever C, which swivels around fulcrum D and through a rod E, which slides in bushings. The disc is driven by a motor, located in the base of the machine. The power is transmitted from the motor by means of a belt pulley and a short flexible shaft. The test piece F is cooled by a stream of suitable liquid, which also carries away the chips formed under the disc. As may be seen from the photographs of the machine reproduced in Figs. 2 and 3, the test piece is clamped in a universal vice, which can move up and down in the guide of the stand of the machine. Before the test is started the vice is levelled in a direction at right angles to the axis of the disc by means of a spirit level, and by lighting up the gap between the test piece and the disc the surface of the test piece is brought accurately parallel with the periphery of the disc. When the piece has been pressed up to the disc and the pointer of the depth gauge is in the zero position the motor is started; at the same time also the small pump for cooling liquid arranged in the base is put into operation. The penetration into the piece is observed by the depth gauge, and the revolutions of the disc are counted. After a specified number of revolutions the machine is stopped, the vice is let down and a microscope mounted in a joint at the left side of the frame is swung over the impression. A sliding shutter in the microscope makes it possible to measure the width of the impression in units of the microscope and the value of impression is determined from a table in thousandths of a cubic millimetre.

If pieces of hard surface are tested, such as cutting tools

Twenty-one Years of Switchgear Manufacture.

THE history of engineering firms that began in a small way and have gradually built up an extensive business is rarely without interest. Among the electrical firms that had a very modest beginning is Ferguson Pailin, Ltd., of Higher Openshaw, Manchester. On December 1st, 1913, a partnership of six was founded with Mr. Samuel Ferguson and Mr. George Pailin as the active partners, and although at the outset the prospects were anything but good, it is common knowledge that the firm has attained a high position among the world's largest switchgear manufacturers. Some idea of the progress made can be obtained from the fact that while operations were begun with only two workpeople, the number now employed is 1500, whilst the capital has risen from £1000 to £600,000.

The original factory in Edward-street, Higher Openshaw, consisted of a small one-storey building, which, together with an adjoining woodworking shop, covered an area of only 189 square yards. With the many extensions that have since been made, the area occupied by the factory has been increased to 31,000 square yards, whilst the site area is 61,000 square yards.

The partnership came into existence at the time when Ferranti, Ltd., decided to discontinue the manufacture of switchboards, and the new firm took up the development work where that firm left it. Recognising the importance of oil circuit breaker design, the firm has never hesitated to adopt changes when they have been deemed to be necessary. One of the most important was the adoption of the round tank circuit breaker, which, with few exceptions, superseded the older rectangular designs, a change which necessitated the scrapping of existing tools, patterns, and drawings, and the rearrangement of the factory.

Research work undertaken with the object of studying the various methods of controlling the arc under oil has led to the adoption of the oil blast method, utilising a cross-jet explosion pot, a device which employs the arc to effect interruption of a fault. As far back as 1919 rupturing capacity tests were conducted in co-operation with one of the large supply undertakings in the country. Intensive propaganda was carried out by the firm with a view to showing the desirability of testing circuit breakers for breaking capacity, and all reputable switchgear manufacturers are now supporting this policy.

The company's name is so closely allied to the principle of vertical isolation that probably few are aware that its earliest efforts were devoted to the development of horizontally isolated metal-clad gear up to 33 kV. Believing, however, that horizontal isolation did not represent the state of finality, the company struck out on an original line and developed vertically isolated gear, another change which involved the scrapping of tools, &c.

Short-circuit testing is now an accepted part of the company's work, and ample facilities for proving the performance of all products are available at the short circuit testing station operated by the Switchgear Testing Company, in which Ferguson Pailin are financially interested.

The factory itself is equipped with two main testing laboratories—the high-voltage laboratory, in which pressures up to 500 kV can be applied under varying conditions of humidity, &c., and the mechanical test-house, in which static and impulse hydraulic tests can be applied to oil circuit breaker structures and other chambers. Parallel with the technical progress of the company there has been a steady rise in the value of individual orders, which has reached as much as £280,000. Typical examples of the firm's switchgear are given in Figs. 1 and 2, which show respectively the top sections of 33 kV oil-filled gear for the new Tir John North station, Swansea, and 1,500,000 kVA, 11 kV duplicate bus-bar, metal-clad units installed at the Kirkstall power station, Leeds.

FIG. 1—33-KV SWITCHGEAR TIR JOHN NORTH

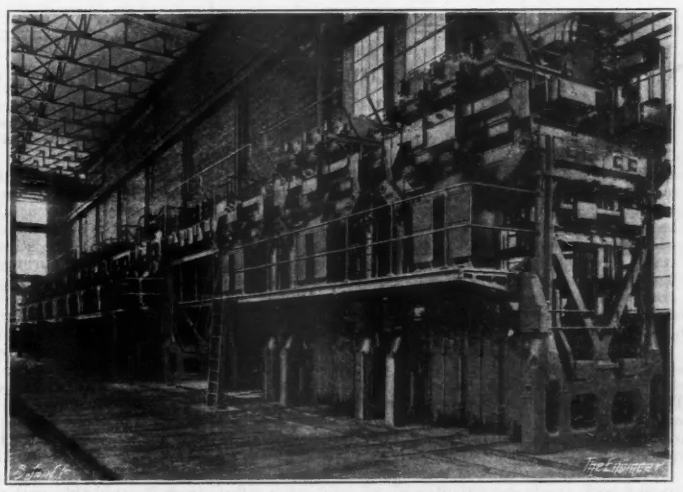


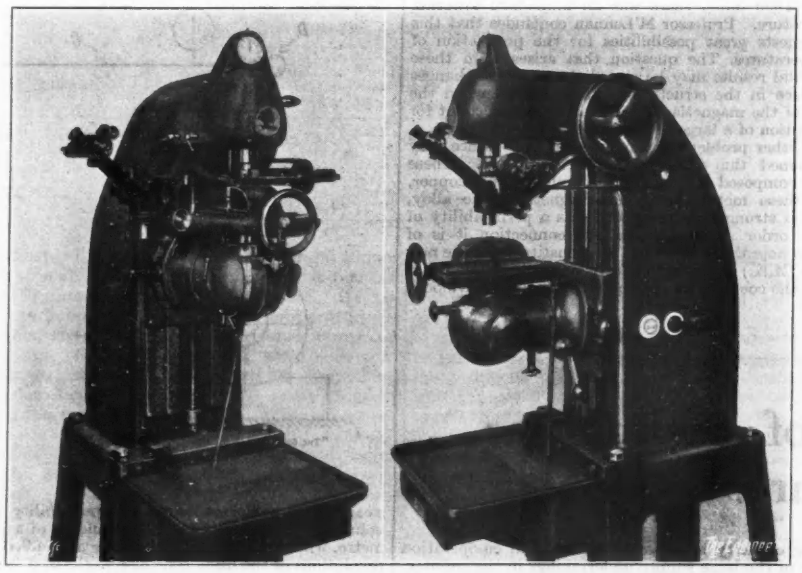
FIG. 2—11-KV SWITCHGEAR—KIRKSTALL

A FACTORY is to be opened at Nitshill, near Glasgow, for the manufacture of welding electrodes.

and measuring instruments, tools of Stellite and Widia, case hardened or nitrided machinery parts, the Widia disc should be 25–30 mm. in diameter, 2½ mm. wide, and should run at 675 r.p.m. and at a pressure of 15 kilos. For cooling, a ½ per cent. solution of potassium dichromate in distilled water is used. The total number of revolutions of the disc working continuously should be 3000 + 10, which corresponds to a duration of the test of about 4¼ minutes.

In a comparison of the wear of Zeiss block gauges of tool steel and of Poldi maximum high-speed steel, tested by the Skoda-Sawin machine, it is interesting to find that the gauges of high-speed steel had an amount of wear equalling 40, whereas the gauges of carbon steel of the same Vickers hardness, 802, had a much greater amount of wear, *i.e.*, 106. This relation is borne out in practice.

As the volume of the impression increases proportionally with the number of revolutions of the disc, or with the period of duration of the test, it is possible to carry out by



FIGS. 2 AND 3—WEAR TESTING MACHINE

this machine tests on all kinds of material. If tests of soft materials are to be carried out, the duration of the test can be shortened and the results converted to the normal number of revolutions of 3000, which have been fixed for the tests of hard surface pieces. Tests can also be carried out on the basis of a constant volume of impression observed by a depth gauge, in which case the wear is measured by the period of duration of the test.

It has been ascertained that even the slightest change of composition of the cooling liquid has an influence upon the results and that the Skoda-Sawin machine can consequently be used with advantage also for testing various kinds of lubricating oils, emulsions, and solutions used as cutting liquids.

North Wilford Generating Station, Nottingham.

THE extensions to the boiler plant for North Wilford power station consist of four powdered fuel-fired International Combustion, Ltd., boilers, each of a normal continuous evaporation of 175,000 lb. per hour and maximum continuous evaporation of 200,000 lb. per hour, the steam at the stop valve being 625 lb. per square inch at a temperature of 800 deg. to 850 deg. Fah. and the feed temperature 240 deg. Fah. The boilers are of the Lopulco steam generator design with a completely water-cooled combustion chamber of closely spaced bare tubes and having a water screen of wider spaced tubes over the ash hopper.

The superheater will be of the M.L.S. type, situated at the top pass of the boiler, and will have horizontal elements. The heating surface will be 4750 square feet. The boiler drums and steam receiver will be solid forged with swaged end, the main steam drum being 4ft. 6in. internal diameter and 4¼in. thick. They will be supported by slings from the boiler structure.

A convection rear bank of boiler tubes is to be installed integral with the boiler circuit, and, in addition, a gilled tube type economiser will be provided to raise the feed-water temperature from 240 deg. to 288 deg. Fah. on normal load. An Usco plate type air preheater will be provided after the economiser to reduce the leaving gas temperature from the heater to 280 deg. Fah. on normal load, thereby raising the air temperature to 452 deg. Fah.

There will be two induced draught and two forced draught fans per boiler, and each will be capable of operating the boiler at 75 per cent. of the normal load. The induced draught fans will be fitted with vane control equipment, and driven by two-speed squirrel-cage motors, but the forced draught fans will be operated by commutator motors.

The milling plant is to consist of two Raymond Lopulco mills and exhausters per boiler, with direct-firing burners situated at opposite corners of the combustion chamber. The capacity of each mill is approximately 6 tons per hour, the fineness of grinding being 80 per cent. through 200 B.S.S. sieve.

The gases from the boilers after leaving the induced draught fans will be discharged to a washing chamber situated on the roof, the supply for which is to be obtained from the circulating water system. In this chamber the ash in suspension in the gases will be entrained and brought down. The gases will then pass on to a common stack per pair of boilers situated on top of the boiler-house roof, 15ft. 6in. diameter, and of a total height of 240ft. above basement level, constructed of copper bearing steel in order to resist corrosion. Provision is, however, being allowed for lining the chimney at a later date if desired. The gas chamber washings will be taken to a Hardinge thickener and Rovac filter, by which the ash will be removed from the slurry in a condition in which it may be readily handled, and the surplus water returned to the river. The soot and dust collected from various hoppers in the boiler will also be led into the same system, but the clinker from the ash hoppers under the boilers will be sluiced into a swirl pit and pumped out on to waste land.

The boiler plant will be located in a steel-framed brick-panelled new house adjacent to the present buildings, with the fan floor arranged above the boilers, and having bunkers to contain approximately 1000 tons of coal, this being sufficient for twenty-four hours' operation of each boiler at normal load. The floors and galleries will in general be of open type steel flooring.

For supplying the bunker, a 60-ton per hour capacity Usco coal-handling plant is to be installed, comprising tippler and weighbridge, duplicate elevators, and conveyors. A siding for coal trucks runs immediately alongside the new boiler-house building.

The foundation work for the boiler-house is being undertaken by the City Engineer and Surveyor's department. Considerable care has had to be exercised during the construction to guard against ground water pressure, and this has called for speedy installation of the foundations.

SIXTY YEARS AGO.

THOSE of our readers who have visited the offices from which this journal is published will recollect that Essex-street, leading from the Strand to the Embankment, is blocked at its lower end by an ancient building. This building—sometimes erroneously described as a water-gate—is pierced by a tall arch through which a narrow flight of stairs leads the wayfarer down to the level of the Embankment. The street and its immediate neighbourhood have had a curiously mixed history. Essex House was built in 1570 at the Strand end. It was from this house that the great earl, fallen irrevocably from Elizabeth's favour, sallied forth on his futile insurrection. To it he speedily returned to defend himself, hopelessly as it proved, behind barricades, and from it he passed to the Tower and the block. In those days the site now occupied by Essex-street was a portion of the Earl's garden and sloped steeply down to the river. It remained in that fashion for about a hundred years until in 1675 Nicholas Barbon took it over for the purpose of erecting dwelling-houses upon it. Essex House was demolished but to overcome the slope of the ground Barbon took an archway from it—probably part of the entrance from the Strand to the courtyard—and re-erected it towards the foot of the garden. On either side he buttressed the archway with a dwelling-house and thereby created an abutment against which he could build up a level roadway on the Strand side. There was no thoroughfare through the archway in those days. The steps were not added until many years later. At one time the ground beyond the archway was largely a marshy, foreshore. An old map shows a dock or wharf to have existed a little to the west. The land, in time, was reclaimed and brought to its present form about seventy years ago when the Victoria Embankment was built, with the Underground Railway beneath and Temple Gardens above. Sixty years ago anyone descending the steps through the archway would have found on his left the boundary wall of the Middle Temple much as it still is. Immediately on his right he would have observed the works of Messrs. Gwynne, hydraulic engineers and beyond the printing establishment of Woodfall and Kinder. Further west he would have seen new headquarters being erected for the London School Board. To-day all these buildings have vanished. Astor House, a gem of architecture, now occupied by the Society of Incorporated Accountants and Auditors, stands on the site of Messrs. Gwynne's works. Four or five years ago the old School Board's building was demolished to provide a site for Electra House, the home of Cables and Wireless Ltd. Had our wayfarer of sixty years ago returned to the Strand the first object which he would have seen on emerging from the end of Essex-street would have been the new Law Courts, then approaching completion. He would have noticed Wren's Temple Bar, shored up but still spanning the roadway and would doubtlessly have wondered, as many others were wondering, what was to be done with it. It was not only a nuisance to traffic; it was dangerously decayed and was quite out of harmony with the new Law Courts. In our issue of December 4th, 1874, we proposed a solution of the problem and illustrated it by means of a "what-it-would-look-like" picture. We proposed that the archway and Barbon's houses at the end of Essex-street should be pulled down and that on the site thus cleared Temple Bar should be re-erected, with a bold flight of steps leading from it down to the Embankment. On the whole we feel glad that this scheme did not meet with official approval, that Temple Bar was removed to Lady Meux's country park and that the Essex House archway was allowed to remain to remind us of the history of the street to which it and we belong.

NEW POWER PLANT FOR CHINA.

IN connection with the development of a new port for the Chinese State Railways in Honan, the Fraser and Chalmers Engineering Works of the General Electric Company, Ltd., Erith, Kent, has just secured a contract for a complete power station, a coal storage, reclaiming and shipping plant, and handling equipment for general merchandise.

The power station will house four steam turbo-alternators, two of which are now in process of manufacture; each will comprise a Fraser and Chalmers geared turbine of the standard high-pressure type, coupled to a "Witton" alternator rated to develop a normal output of 500 kW.

The coal handling plant will be provided with a wagon tippler to handle all trucks from 10 to 40 tons capacity, tipping through belt feeders on to storage conveyors, which will make, through a mechanically propelled tripper, a stock pile 60ft. high and about 1600ft. long. Under the pile will be a concrete tunnel for reclaiming the coal through gates on to a conveyor, and then on to the wharf to load vessels through the medium of a travelling tower with an outreach of about 70ft. It will be possible to ship direct incoming coal by short-circuiting the stock pile and delivering directly on to the conveyor in the tunnel.

The capacity of the plant is to be 400 long tons per hour of run-of-mine coal, and of the stock pile 84,000 tons live storage or 167,000 tons total storage. The coal will be automatically weighed into the stock pile and also into boats by belt weighers. In all over 5000ft. of 30in. belt conveyors will be installed. For handling merchandise at the port the plant will include three 3-ton electric level luffing cranes, four 2-ton overhead travelling cranes, two 2-ton mobile electric cranes, and six gravity roller conveyors, each 24ft. long, for conveying packages and similar merchandise.

THE INSTITUTION OF ELECTRICAL ENGINEERS.

AT the informal meeting held on Monday, November 26th, at the Institution of Electrical Engineers, Colonel G. D. Ozanne, M.C., opened a discussion upon "The Modern Electric Vehicle."

He said that there is no doubt that the adoption of electric vehicles in this country and in most other countries other than Germany and America had been very slow. The inauguration of the hire arrangement of the battery would undoubtedly do a very great deal to increase the use of these vehicles. The speed of electric trucks, varying from 3 to 6 m.p.h., although it might seem low, was ample for all works purposes. The turning radius was very small and where four-wheel steering was provided could be brought down to 3ft. or 4ft. from centre of truck. The radius of action of a truck on one charge was usually 15–25 miles, and it was quite practicable to obtain this under ordinary working conditions by charging the battery overnight. It was most important that the size of the battery should be regulated according to the work. Sometimes, however, distances were very long and working hours were extended, and in that case it was usually better to change the battery over in the middle of the day and put in a spare one. For road vehicles the chassis was of lighter construction, as loads were less and conditions not so severe. Pneumatic tires were almost universally fitted. A speed of 25 m.p.h. was easily attained. A special type of traction motor was fitted and hills could be negotiated very easily without much loss of speed. There were electric vehicles which were climbing gradients of 1 in 6 without undue heating of the motor or excessive drain on the battery. One manufacturer had recently designed a dual motor which was essentially two motors in one frame. By this means a really powerful motor was obtained for climbing severe hills at a moderate speed and a high-speed motor was available for use on the level. Another type of vehicle was the three-wheeler, specially designed to provide an extremely small turning radius. This vehicle was fitted with a controller and steering lever which could be operated from the side, enabling the roundsman to move from door to door without having actually to enter his vehicle. There was a tendency on the part of purchasers to allow insufficient battery capacity, and it was most important to examine the particular country and insist on the battery recommended being fitted. However, 15–20 miles per day was the average mileage for local delivery. Owing to the very smooth acceleration and evenly controlled speed, the wear and tear of tires was very low indeed. Those vehicles were almost silent and that was a very important point, especially when considering such things as milk delivery in the early hours of the morning.

Railway and Road Matters.

Answering a question addressed to him on November 27th, Mr. Hore-Belisha said that the railway companies had assured him that they were keeping in close touch with all developments that are taking place in connection with high-speed railroad transport.

WITH another month to go before the end of the year, two of the four grouped companies already have passed the two-million increase in traffic this year, when compared with 1933. The L.M.S. reports an advance of £2,141,000, or 4·13 per cent.; the L.N.E. is up £2,022,000, or 5·33 per cent., whilst the Great Western has an increase of £588,000, or 2·67 per cent., and the Southern, £399,000, or 2·24 per cent.

IT was twenty-five years ago on December 1st since the London, Brighton and South Coast Company's electrical service between London Bridge and Victoria, over the South London line, was opened. The loss of traffic from the competition of tramways inspired that work; additionally, there was the hope of electrical operation between London and Brighton, and possibly on to Portsmouth. For this the railway company had obtained powers in 1903. Originally, it was not proposed to run into either of the London termini named, but that decision was subsequently amended and six platform lines and three approach roads were equipped at London Bridge, and five platform lines and two running roads at Victoria.

THE late Sir Robert Perks, who died on Friday, November 30th, was the chairman of the Metropolitan District Railway during the period when its conversion to electric traction was being undertaken by the Underground Electric Railways of London Company. Lieut.-Colonel Sir William Hutchison Poë, who died on the same day, one eighty-five years of age and the other eighty-six, was a member of the Viceregal Commission of 1906–1910 on Irish Railways. Sir William was one of the four—two others were Sir Charles Scotter and Lord Pirrie—who signed the majority report. It may be of interest if we add that the three who signed the minority report were Sir Herbert Jekyll, Sir William Acworth, and Sir John Aspinall.

THE fatal derailment of November 27th at Wormley, near Broxbourne, L.N.E.R., of a passenger train through it striking a motor vehicle at an occupation level crossing was inquired into, on behalf of the Ministry of Transport, by Colonel Trench on Monday last. The evidence showed that it was foggy at the time, with a visibility of from 150 to 175 yards. There is a signal-box near the crossing, but apparently the signalman exercises no control over its use. Some fifteen or twenty vehicles cross daily, and some of their drivers ask if the line is clear. The signalman thought that if the motor driver had looked at the signal he would have seen it plainly. The inquiry was adjourned until December 12th to allow the driver of the road vehicle, who is in hospital, to give evidence. The coroner's inquest was opened on Saturday, the 1st, and, for the same reason, was adjourned until December 10th.

AT the present time there are, from a point near Finchley-road, six lines of way up to Harrow North Junction, of which four are used by what, for convenience, we will call the Metropolitan trains from and to Baker-street, and the other two are for the L.N.E.R. trains from and to Marylebone. At Harrow two lines turn to the west and proceed to Uxbridge and four converge and proceed northwards to Rickmansworth, Aylesbury, and the former Great Central Railway. The London Passenger Transport Board's parliamentary proposals for the new session include the quadrupling of the line between Harrow and Rickmansworth. The Metropolitan electrical services now terminate at the latter station, and it is also proposed to carry these forward to Amersham. It is interesting in this connection to remember that the section of line north of Harrow is jointly owned with the London and North-Eastern Railway.

THE first railway in Ireland was opened one hundred years ago. It was the Dublin and Kingstown, which was sanctioned by 1 and 2 Will. IV c. 69 of September 6th, 1831, and was opened on December 17th, 1834. In 1838 it was carried forward to Kingstown Harbour. It was a very valuable piece of property, and when it was leased by the Dublin and Wicklow Railway in 1846 the amount to be paid by the latter was £32,000 a year, and, should the gross receipts reach £55,000 a year, the Dublin and Kingstown was to have 30 per cent. of the gross receipts above that sum. Bradshaw's "Railway Manual" for 1858 reported that the dividends had been equal to 8 per cent., but in the previous August the traffic had reached the stipulated amount, and the extra payment was accordingly being made. For many years the dividend reached 9½ per cent., but tramway competition then hit the railway very badly and from July 1st, 1905, the rent was reduced to £30,000 a year, and the stipulated amount was raised to £75,000 per annum.

THE report by Mr. J. L. M. Moore on a fatality in Dove Holes Tunnel on the Derby-Manchester section of the L.M.S. Railway, on February 4th last, shows the need for obedience to the minor detail in the operating rules. The occasion was during some single-line working necessitated in order to relay part of the down line. All traffic had to be worked over the up line under the control of a pilotman, and one of the instructions to be obeyed by him was that men working on the line were to be told what was being done. The pilotman on the light engine, which opened the single-line working on this occasion, ran past the men without stopping to advise them. In addition to the general rules as to using the engine whistle freely when passing through long tunnels, there is a special instruction as to the whistle being "popped" when travelling over a line in the wrong direction. That is intended as an indication that something unusual is taking place. The fatality in question occurred to a man who stood with others along the wall on the down side waiting for some smoke and steam to clear away. He apparently was under the impression that the down line was still open, and hearing the warning horn and shouts to "look out, down road," he crossed to the up line, for, as he thought, greater safety, and was killed by a down goods train running on the up line.

Notes and Memoranda.

THE number of electrical accidents reportable under the Factory Acts in 1933 numbered 346, compared with the averages for the two previous five-year periods of 384 and 368, during which time the kWh sold by authorised undertakings increased from 4339 million to 10,097 million and the number of factories covered by the Regulations from 72,820 to 122,288.

A NEW method of securing rails to sleepers which has been patented in Germany is described in the *Railway Gazette*. It consists of straps to which the sole plate is fastened, encircling the sleeper, and thus avoids the necessity of drilling holes in the sleeper at the points where it has to sustain the highest stress, namely, where it carries the rails. The new method is suitable for any type of sleeper, wooden, steel, or concrete.

AT a meeting of the Chemical Engineering Group of the Society of Chemical Industry, Colonel W. A. Bristow said, in a paper on "The Chemical Engineering Aspect of Low-temperature Carbonisation," that the average yield of products from 1 ton of good washed bituminous smalls was approximately :—Smokeless fuel, 14 cwt.; crude coal oil, 18 gallons; crude petrol, 3 gallons; gas, 30 therms; ammonium sulphate, 4 lb.; liquor, 20 gallons.

AT a recent meeting of the Newcastle Chamber of Commerce, Sir Arthur Sutherland said that in 1911 he had a steamer of 7800 tons deadweight built at a cost of £38,000. To-day, a similar ship would cost £60,000, and if she had superheating and other improvements would cost £65,000. That was 50 per cent. above pre-war cost. The ship he referred to he put on time charter for twelve months at 3s. per d.w. ton; to-day, he could not get more than 2s. 6d. Before the war the wages bill was £180 per month; now it was £300.

THERE is considerable possibility, according to the *Shipping World*, of a new coal-oil industry being established on Tees-side only a few miles from Imperial Chemical Industries' hydrogenation plant at Billingham-on-Tees, which is almost completed. Coal and Allied Industries, Ltd., formerly Motor Fuel Proprietary, Ltd., which has been formed with a capital of £175,000, has secured an option on a site on the north bank of the Tees near Seaton Carew. The plant is estimated to cost £150,000, and will be capable of treating 500 tons of coal daily. Durham coal is believed to be particularly suitable for the process which it is intended to operate.

IN the course of discussing a paper on "Turbines for Tramp Ships," Mr. R. J. Walker said that a few years ago the Cairn Line had obtained alternative tenders for various types of propelling machinery, and proceeded to quote some comparative figures. Assuming the ordinary triple-expansion engine with saturated steam at an index figure of 100, the alternative of triple-expansion engines with superheated steam gave 104·7. With quadruple-expansion engines, saturated steam, the figure became 112·8, and with quadruple-expansion engines, superheated steam, 117·4. The figure for geared turbines with superheated steam was 128. The Cairn Line decided to fit geared turbines to two of their vessels, as it was considered that the annual saving in running expenses which included fuel, cost of upkeep and other economies, would warrant the additional initial expenditure.

IN a letter to *Nature*, Mr. Theodore H. Beard, supervising engineer, Dictaphone Corporation, Bridgeport, Connecticut, says :—"Some readers may be interested to know that dry ice is used regularly by one of our large automobile companies. The exhaust valves on the cars manufactured by the concern in question seat on a ring of heat and corrosion-resisting material set into the cast iron of the block. The ring is made oversize by the required amount and is shrunk by means of dry ice. As the motor blocks pass by on a conveyor the rings are removed from the dry ice refrigerator and are slipped into place in the block. As they come up to room temperature they, of course, expand and are held firmly in place. There would seem to be many advantages in making this type of a fit. Certainly in the case mentioned, the other way of inserting the rings, namely, by heating the cylinder blocks, would be expensive and inconvenient."

DISCUSSING the use of the photo-electric cell in the chemical industry, in a recent paper, Mr. J. A. Walter said that control work demanded a cell of great sensitivity, which could easily be coupled with amplifier circuits to obtain the necessary power for control, but cells to be used for measurement had consistency or accuracy as a fundamental quality. There were three main types, the conductivity cell, the emission cell, and the rectifier cell. The first was most sensitive and could be coupled to amplifiers; the rectifier cell came next, but had too low an internal resistance for easy amplification; while the vacuum emission cell had the lowest sensitivity, but was easily adaptable to amplification. So far as consistency and accuracy were concerned, the conductivity cell was quite unsuitable; the vacuum emission cells were best in that respect, but the rectifier cells were a very good second, and were often employed for measurement on account of the simplicity of their associated circuits.

PREVIOUS investigations into the ignition of fire-damp by coal-mining explosives have led to the conclusion that such ignitions might be due to the flame from the explosive, the shock and pressure waves of the explosion, or the projection of particles in a chemically active state. While these factors may not be separable in practice, attempts are being made to examine them independently by experiment. A recently issued Safety in Mines Research Board paper by Messrs. W. Payman and D. W. Woodhead is a preliminary account of a study, by means of Schlieren photography, of the differences between the pressure wave sent out by an explosive charge capable of igniting a fire-damp-air mixture and the corresponding wave from a non-igniting charge. Certain differences have been observed between the waves from the two types of charge, but the most noticeable features of the records were disturbances, secondary to the main shock wave, which occurred with both safe and dangerous charges. The occurrence of these secondary disturbances is discussed in the paper, and possible explanations as to their character are advanced.

Miscellanea.

THE second 20-ton, 200in. diameter glass mirror casting for the world's largest telescope has been successfully poured at the Corning glass works, U.S.A.

THE Japanese Ministry of Communications has decided to install wireless apparatus in the telegraph offices of all important cities, to be used in cases of emergency.

AT the end of last year there were 458 registered trade unions in this country, with a total of 3,346,662 members, and having aggregate funds amounting to £11,760,465.

AT an estimated cost of £40,000, a new paper mill is being built at Brampton, Chesterfield. Special equipment for the manufacture of cellulose wadding is being installed.

A PRIZE of £125,000 has been offered by the French Air Ministry to the constructor of the first crude oil motor which will enable an aeroplane to average more than 93 m.p.h. over a closed circuit of 6240 miles.

ACCORDING to a report issued by the Dominion Bureau of Statistics, there are now 94,721 miles of surfaced roads in Canada, compared with 91,845 miles in 1932, and a total of 409,124 miles of all classes of roads, as against 388,094 miles for 1932.

SINGAPORE municipality has decided to raise an 8,000,000-dollar loan to perfect the sewerage of the town. New disposal works are to be constructed at Paya Lebar. The outflow is to be poured into Serangoon River and by bio-flocculation treatment will be entirely free from smell.

THE suggestion is made by K. W. Willans that, in view of the great responsibility of engineers for the present economic situation, each engineering society should devote an evening to debating the problem, on a motion supplied by its own Council, or on a motion formulated by a gathering of all the Councils in council.

ACCORDING to the Rome correspondent of the *Daily Telegraph*, Italian shipbuilders will receive a special bounty for increasing the speed of their Transatlantic liners to a minimum of 20 knots, or at least 3 knots above their present maximum average speed. The new engines must be put in not later than June 30th, 1938. It is calculated that several liners will be able to do 21 knots.

THE announcement in the House of Commons that Scotts' Shipbuilding and Engineering Company, Ltd., Greenock, was—subject to certain adjustments—to build a cruiser under the Admiralty's 1934 programme, places the firm in the enviable position of having on hand at the same time two cruisers, two destroyers, and a submarine, says *Shipbuilding and Shipping Record*. It has just completed the destroyers H.M.S. "Escort" and H.M.S. "Escapade," under the 1931 programme, has about six months' fitting-out work on H.M.S. "Galatea," a cruiser under the 1932 programme, and has H.M.S. "Swordfish," a submarine under the 1933 programme, on the stocks. Already the firm has received a contract for two destroyers under the 1934 programme. The latest cruiser will mean work for at least 2000 men for upwards of two years.

THE Beauharnois Power Corporation, through its operating subsidiary, the Beauharnois Light, Heat, and Power Company, Ltd., is now delivering 204,000 h.p. of electrical energy under its contracts with the Montreal Light, Heat and Power Consolidated, and the Ontario Hydro-Electric Power Commission. Montreal is taking 75,000 h.p., and the Ontario Hydro 129,000 h.p. By October, 1937, they will be receiving 150,000 h.p. and 250,000 h.p. respectively. The Beauharnois Power Corporation is engaged in developing 500,000 h.p. on the St. Lawrence River. About a quarter of the flow of the river is being diverted through a new canal around the Beauharnois section of the river. In addition to developing hydro-electric power, the new channel will complete the canalisation for deep-water navigation of all the wholly Canadian sections of the St. Lawrence save for the stretch around the Lachine rapids at Montreal.

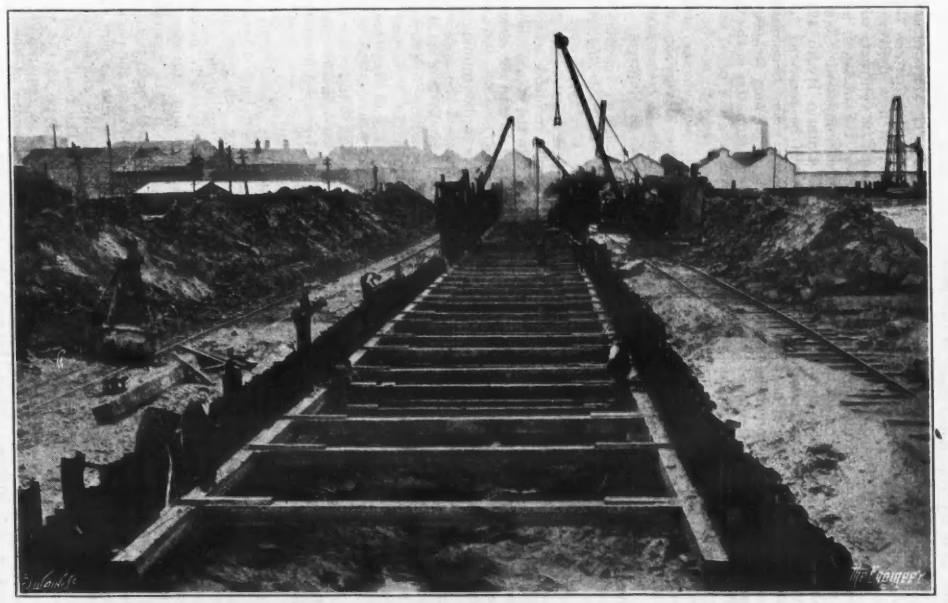
LECTURING before the Junior Institution of Engineers on November 30th, Mr. G. S. Irving, A.M.I. Chem. E., defined "priming" as a carrying over of droplets or "slugs" of water, such droplets being due to the rapid bursting of steam bubbles resulting in spurting, spitting, and spraying of water into the steam space; and "foaming" as a froth mounting up into the steam space and the bubbles passing through into the steam pipe. Both effects often led to errors in determining the efficiency of a boiler, since they increased the apparent evaporation. Foaming, he said, often gave little or no signs at the boiler end, but might be detected by its effects and would be indicated at steam traps, &c. Normal quality steam contained about 1 per cent. of moisture, but owing to foaming or priming that figure might reach 5 per cent. or over. If oil gained access to the boiler and it contained a small percentage of saponifiable matter, persistent foaming might be caused by saponification in an alkaline feed water.

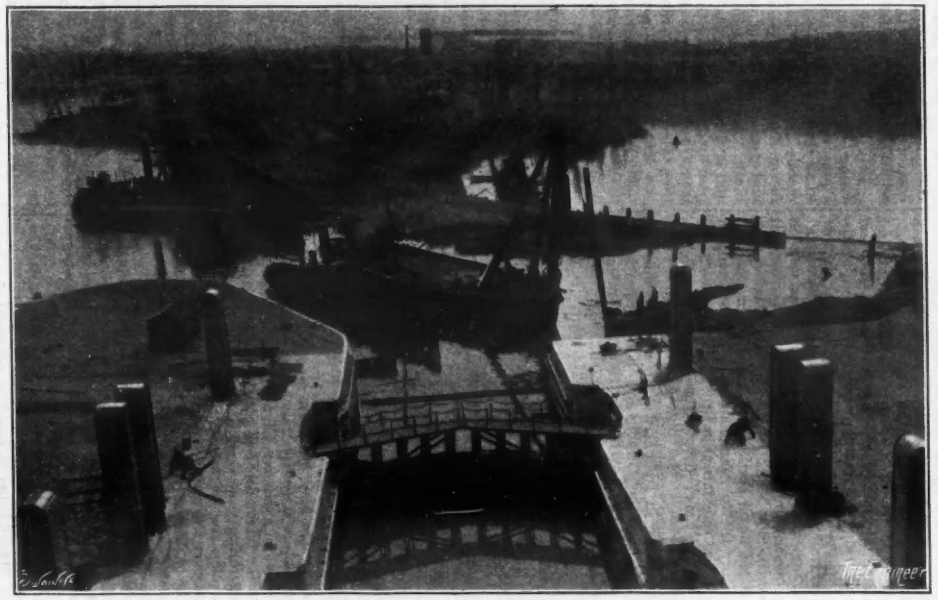
SOME particulars of the "Kenilworth," the new oil-electrically driven paddle ship for the London and North-Eastern Railway Company, are given in the *Electrical Review*. The main power equipment will consist of two 400 h.p. heavy oil engines specially mounted and slung on springs to avoid noise and vibration. Each engine will be directly coupled to a D.C. generator, which will supply power, either separately or in parallel, to a double-armature D.C. motor mounted on the paddle shafts. The engines and generators will run at 600 r.p.m., but the motor will run at such a slow angular velocity that no gearing will be required. The boat is expected to be the fastest "paddler" of her type in the world, 17 knots being the specified speed. A remarkable feature of her equipment will be the absence of the usual telegraph between the bridge and the engine-room. The officer on the bridge will have complete control and will be able to manœuvre the ship by operating control levers as if he were driving an ordinary electrical land vehicle. The double-armature motor will permit the paddles on port and starboard to be driven one forward and the other astern, in addition to the usual dead slow, half, and full speeds.

NEW FISH DOCK AT GRIMSBY

SIR JOHN WOLFE BARRY AND PARTNERS, CONSULTING ENGINEERS

(*For description see page 558.*)





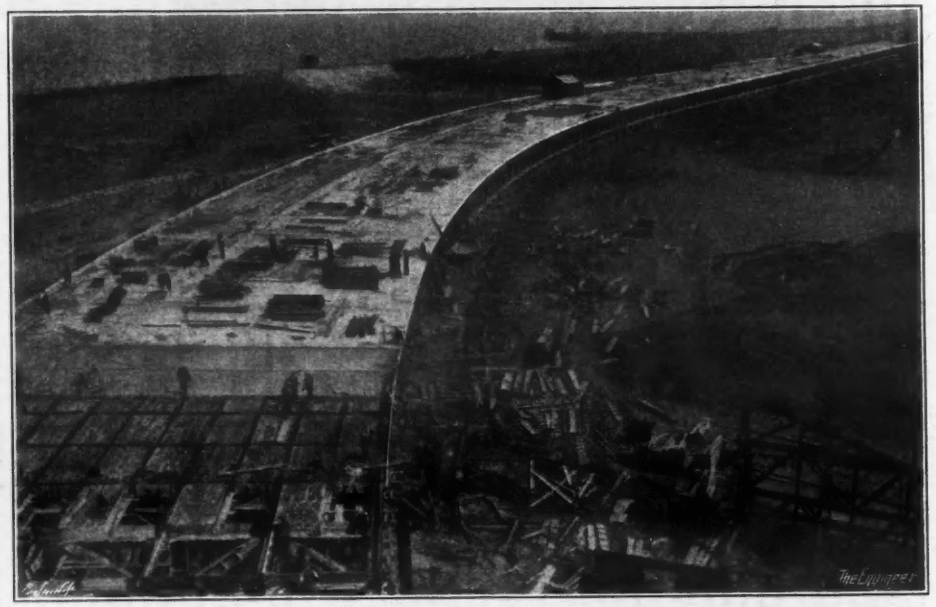


FIG. 10 (ABOVE):—EXCAVATION IN SEWER DIVERSION TRENCH—JUNE, 1931

FIG. 11 (BELOW):—INNER END OF NEW ENTRANCE LOCK—REMOVAL OF CAMPBELL'S JETTY

FIG. 12 (ABOVE):—EXCAVATION IN DOCK AREA—MARCH, 1933

FIG. 13 (BELOW):—NORTH QUAY—JUNE, 1933

The Engineer

DECEMBER 7, 1934.

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NOTICES TO READERS.

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THE ELECTRICITY BILL.

ON Thursday, November 29th, the House of Commons passed the Second Reading of "A Bill to authorise the Central Electricity Board to make certain arrangements with authorised undertakers who are the owners of, or control, generating stations which are not selected stations; to authorise the Central Electricity Board to supply electricity directly to railway companies for certain purposes; to amend sections eleven and twelve of the Electricity (Supply) Act, 1926; and for purposes connected with the matters aforesaid." In Section 4 of the Bill we read that "the Central Electricity Board may supply electricity directly to any railway company upon such terms and at such prices as may be agreed," provided that the "agreement will not result in a financial loss to the Board"; and that "Electricity supplied to a railway company under this section may be used for the haulage or traction of vehicles used on the railway, on any part of the system of the company, and for the lighting of the vehicles, for the haulage or traction of which electricity so supplied is used." Furthermore, with the consent of the Minister of Transport, the electricity thus supplied "may be used partly for such purposes as aforesaid and partly for other purposes of the company's undertaking."

There can, we suggest, be no doubt whatever about the ultimate intention of this Bill. Briefly, it aims at the resuscitation of the Weir report and the electrification of the complete railway system of Great Britain. But it goes still further, for, as the Federation of British Industries has pointed out in a letter which we summarised in our "Journal" last week, it seeks to make the Central Electricity Board a direct trader of electricity to consumers. In the case of railways it will, if the Bill reaches the Statute Book, sell direct to the companies. That is manifestly but the first step towards complete national control of the railways and, in the end, their acquisition by the State. To what other courses, equally undesirable, it may lead no one can say, but from the satisfaction with which the Bill is being received by the Socialists, it is evident that they foresee great possibilities in it. It may be taken for granted that some day or another the railways will be nationalised. Probably the railway companies will be the last to object to that course if they be properly compensated. Hampered by restrictions and faced by competition on the road and in the air, they may not be sorry to be quit of a property which has become a burden to them. If there are any objectors, they will be found amongst the general public if, by then, any of the old principles which have successfully guided the policy of this country for many hundred years are still respected. All that may be left to the future. Our present anxiety turns upon the immediate effect of the Bill. As we have said, its object is the electrification of all the railways of this country, principally, it cannot be doubted, for the benefit of the "Grid." It will be recalled that the Weir Committee envisaged the thorough and complete electrification of every yard of companies' railway in the country, and that on that assumption it based its estimate of economies and the cost of the undertaking. That cost, we may remind our readers, reached the enormous figure, for capital expenditure, of 261 million pounds by the railway companies and "about 80 million pounds by the Central Electricity Board and other authorities, apart from the extra expenditure necessary in order to realise an intensive suburban development." This colossal commitment amounting to at least 350 million pounds killed the proposals when the Weir Committee reported in March, 1931. That the present Bill is unquestionably directed towards the revival of the scheme is evident when it is recalled that the Weir report recommended that "the Central Board be given power to afford direct supplies for railway electrification schemes"—the main object to which the Bill is directed.

We need not at this stage recall the familiar arguments against main line railway electrification, but we may say that in the three and a-half years which have elapsed since the Weir report was published nothing, on the one hand, which makes electrification more palatable has occurred, whilst, on the other, the independent locomotive, whether self-propelled by steam or oil engines, has made considerable progress. What the repercussions of this Bill upon this progress may be it is not very difficult to imagine. If it is the avowed intention of the Government to proceed with main line electrification at all costs, there can be little or no reason why the railway companies should foster new devices for increasing economy or new means of improving their services. It is true that the Weir Committee gave half-hearted encouragement to the internal combustion locomotive for "lightly loaded branch lines," yet it is scarcely possible to doubt that all those who have been and are working on it will be discouraged by the Act if it becomes law. But the health of the oil engine, in all forms, is a matter of more than indifference to the grid authorities. They have already done their best to stamp it out for the generation of electricity and they will now do what they can to ruin its prospects for railway propulsion. If the electrification of British main line railways was manifestly desirable in the national interest there would not be a word to say against the deletion of other forms of operation, but when we suspect that electrification is sought for less excellent reasons, then those industries which are likely to suffer by its adoption are right in opposing a measure which may seriously damage them without benefiting the country as a whole.

Railway Level Crossings.

THERE are three kinds of level crossings over railways—(1) that of the highway or public road, (2) the accommodation or occupation crossing, (3) the public footpath. For our present purpose, it will be convenient to dispose at once of the last-named kind. When a railway is constructed across a public footpath the right of way, unless its abolition has been sanctioned by the enabling Act, must, under common law, be maintained. Furthermore, by Section 61 of the Railway Clauses Act, 1845, the railway company must make and at all times maintain good and sufficient gates or stiles. Footpath crossings cannot be regarded as a serious public danger; their users are conscious that they run a risk when crossing the line, and, as a consequence, only some eighteen persons are killed when using such crossings in a year. Public road crossings are those with which most people are acquainted. They are a greater nuisance than danger, because of the delay they cause to road traffic. From the earliest days of railways their provision has been jealously watched by Parliament. It was required that any new railway, if it had to cross any turnpike road or public highway, had to do so by taking the road over the railway by an overbridge or the railway across the roadway by an underbridge. Any deviation from this standard requirement was to be specifically provided for in the Act. The Parliamentary Standing Orders state that no railway shall be authorised to cross any public road on the level unless a report from an officer of the Board of Trade—now of the Ministry of Transport—has been obtained and laid before the committee which is considering the Bill, and should the committee, contrary to the advice given by the officer, recommend any such crossing, it shall report the reasons and facts upon which its opinion is founded. As far back as 1835, and again in 1839, mainly through the influence of the landed gentry, the railway, at turnpike roads and highways, had to be fenced off from the roadway by good and sufficient gates which, when open for road traffic, had to close the railway so as to prevent horses and cattle straying on to the line, and which were to be opened and closed as required by good and proper persons. The Act of 1845, mentioned above, required a lodge to be erected at all public road level crossings, and it went as far as to authorise the Board of Trade, on complaint of danger to passengers by road in consequence of horses being frightened by the sight of the engine or carriages, to require a railway company to construct works in the nature of a screen near and adjoining the side of such road. The inspecting officers of railways, possibly in view of this attitude of Parliament, have always been particular as to level crossings, and among the tables that have to accompany the notice as to the intention to open a new railway or an extension of or alteration to an existing railway, is one of "all level crossings of public, occupation, private or bridle roads and footways." To-day, they require that the gates at public road crossings shall be protected by signals, suitably interlocked with the gates. As a consequence of this care by the inspecting officers, and equally by the railway companies, only seven people were killed at public road level crossings last year, and six of these were pedestrians; all seven fatalities were due to a lack of proper caution.

It will be obvious that we have been led to consider this question because of the fatal derailment on Tuesday, November 27th, of a passenger train at Wormley, near Broxbourne, L.N.E.R., as a consequence of the engine striking a motor vehicle that was crossing the line. That accident occurred at an occupation crossing—the remaining type of crossing to be noticed. The purpose of such crossings may perhaps best be appreciated if it be remarked that in the relevant Act of Parliament they are included in what are known as accommodation works; in fact, this type is generally legally referred to as an accommodation crossing. The legislation in question recites that "the company shall make and at all times thereafter maintain the following works for the accommodation of the owners and occupiers of lands adjoining the railway:" Such and so many convenient gates, bridges, arches, culverts and passages over, under or by the sides of or leading to or from the railway as shall be necessary for the purpose of making good any interruptions caused by the railway to the use of the lands through which the railway shall be made." The responsibility of the railway companies for the safety of people using an occupation crossing may, from time to time, have been questioned, but all judgments have relieved them of responsibility. The Requirements for New Railways, already referred to, whilst making several conditions as to public road crossings, say simply, as to occupation crossings: "For field, private and occupation road level crossings single gates should be used. They should be hung so as to open away from the railway line." The only instructions issued by the companies to their men are contained in one rule, which is general in its character. It reads: "Gangers or men in charge must close and fasten any gates found open which ought to be closed, and report the circumstances, in order that the persons who are required to keep such gates closed and fastened may be charged with the penalties." Singular to relate, a similar accident to that at Wormley occurred on August 17th, 1928, at Shapreth, on the Hitchin and Cambridge section. There, too, a passenger train struck a motor vehicle at an occupation crossing; the train was derailed and the fireman killed. That accident was inquired into on behalf of the Ministry of Transport by Colonel Trench, who observed that it drew attention to a risk which had only arisen within the previous few years in connection with level crossings, *i.e.*, the risk of the road vehicle derailing the train. Previously, a person who, by neglect of proper

precautions, was involved in an accident, endangered his own life or the lives of his own passengers only. The position was then altered, and it was evident that carelessness on the part of drivers of heavy road vehicles might cause serious risk of a train accident involving a number of lives. Colonel Trench recommended for consideration the provision of additional safeguards in the interests of railway passengers and by whom they should be provided. In supporting this recommendation in his annual accident report for 1928, Colonel Mount stated that, including the Shepreth case, similar derailments had occurred on eight occasions during the five years 1924–1928. In concluding this review of the occupation crossing aspect of the question, we would say that, despite the fact that they are, in a sense, unprotected, only thirteen persons were killed at them during last year; six of these were pedestrians, and seven the occupants of road vehicles.

In all, then, 38 users of level crossings of all kinds were killed last year. That comparatively small figure becomes more remarkable still when it is found that even as recently as twenty years ago—in 1913—no less than 64 persons lost their lives at level crossings, and that the average number for the previous ten years was 66 a year. Of the 64 who were killed in 1913, 22 lost their lives at public road level crossings, 24 at occupation crossings, and 18 at footpath crossings. In reviewing the accidents of last year in his annual report, Colonel Mount made comparisons with the average—51 killed—for each of the five years 1925–1929, and said that, having regard to the growth of road traffic, the figures continued to justify the general conclusion that danger to the public using level crossings in this country is not increasing. That conclusion, it will be appreciated, would have been still more justified had the comparisons been carried farther back. But, whilst we support the Chief Inspecting Officer in thus suggesting that level crossings are a less danger than is generally thought, we admit that public road crossings are costly to the public in the loss they cause by the delay to road vehicles when trains have to pass. The greater use of the road since the advent of the motor vehicle and the less time motors take in comparison with the horse-drawn vehicles, to cover a given distance has increased the cost to the public of those delays. Thus, the grants of 75 per cent. of the cost made by the Ministry of Transport from the Road Fund for the substitution of bridges for level crossings are quite justified.

A Survey of Ships and Engines.*

By LOUGHNAN ST. L. PENDRED, C.B.E., Hon. M.I. Mech. E. (Past-President).

THERE is an old saying that "those who come after see with more eyes than their own," meaning, I take it, that by looking at the things that happened in the past we may see and comprehend better the things of our own time. By an extension of this idea it seems probable that if we draw a curve showing the progress of inventions year by year, or period by period, up to the present, we shall be justified in prolonging the line, thereby getting some hint, some rough indication at least, of the state to which inventions will attain in the future.

It is on this perilous adventure that this lecture sets sail. In it we shall try so to study the ships and their engines of the past and the present that we may form an opinion as to the state which they will attain some few years hence.

Such an effort would be vain were the progress of invention capricious. Fortunately, the history of technology shows that it is not. The development of man's inventions takes place under the hands of man, but it appears that he is as powerless to accelerate it greatly as he is to arrest it. Not the wills of all the anti-mechanisation people in the whole world will check for a fraction of a second the wheel that began to spin a hundred and forty years ago when James Watt produced the rotative steam engine. Invention will continue at its destined speed, no faster and no slower. If we could simplify the history of the motor car, or the flying machine, or whatever invention you please, we should find the fact established, that, despite the better knowledge man may possess, his inventions are constrained by a law of Nature to move forward step by step. He cannot make them progress by large jumps; he must plod slowly forward. Two things restrain him. On the one side his own inability, and on the other the reluctance of the user. The second, as much as the first, is according to law. To rail against shipowners because they were indifferent to the merits of the water-tube boiler, or to reprimand them because they are disinclined to fit superheaters, is like grumbling against gravity because it will produce an acceleration no greater than 32ft. per second per second. The reluctance of the user is a scientific fact not less scientific because it is a human failing, and it must therefore be given due weight as a factor in the curve of progress. The men who can overcome this reluctance, men like George Stephenson of railway and F. Pettit Smith of screw propeller fame, are fully as worthy of our praise as the great inventors themselves.

* * * *

It is noteworthy that nearly all the earliest steamers were designed principally to carry passengers and His Majesty's mails. James Watt remarked once that "wind was cheaper than steam," and it is probable that the owners of merchantmen saw no likelihood of making a profit out of engines. But the Postmaster-General was quick to see the advantage of steam for packet boats, and with passengers there was no question. Novel means of locomotion, even if they are no more than Great Wheels or scooters, always appeal to the human weakness for movement. The steamer added to this attraction the peculiar charm which attaches to travelling upon smooth water. This human trait is amongst the forces to which I alluded in the introduction; we have seen it again in the early days of the motor car and in the aeroplane, which to begin with were essentially passenger-carrying machines. Looking backwards, we may say with certainty that if it had not been for the popularity of the steamer amongst passengers, its coming as a commercial vessel would have been long delayed. It is on record that within four years of the completion of Bell's "Comet" it was not unusual for five or six hundred people to enjoy one-day excursions on the Clyde.

The best history of this exciting period is to be sought in a most unlikely place. In 1822 a committee of the House of Commons sat to investigate roads from London to Holyhead, particularly in connection with the carriage of His Majesty's mails. The committee took its inquiry beyond Holyhead and carried the road, so to speak, across the Irish Sea. In other words, it went thoroughly into the question of packets and its Fifth Report is practically entirely devoted to steamboats. Here may be found not only many data, but a great deal of technical information about the ships, engines, and boilers of the day. To this report there is added as an appendix a table prepared by Joshua Field covering all the steamboats then in existence as far as he was able to ascertain. The table shows the advance made in ten years. In 1812 there were only two boats. In the following year five more were built. Five years later—1818—twelve new vessels were commissioned, and in 1821 no less than thirty-eight, whilst in the first half alone of 1822 twenty-two new steamers took the water. The total number of steamers built in the British Isles was, on June 15th, 1822, 137. The "horses power," as it was called, advanced steadily during the same decade from 9 in 1812 to 110 in 1822. Unfortunately, we do not know exactly what these figures mean, for there was no common basis for the measurement of horse-power, some using Watt's formula and others formulæ of their own. For many years "nominal horse-power" remained in use. Even up to the last twenty years or so it was employed in the agricultural engineering industry, and to this day the horse-power given in Lloyd's Register is a nominal one unless otherwise stated.

It is to be regretted that we know relatively little about the engines of these first twenty years. But we may suspect on pretty good grounds that pistons acting directly on the paddle shaft, as in the "Charlotte Dundas," did not long survive. Engineers of those days did not like crosshead guides, or their equivalents. Probably they found them hard to make and difficult to keep cool. They preferred a straight-line, or nearly straight-line, motion, and the bell-crank, the inverted beam, and the grasshopper engines became more or less standardised in this country in order to save height. But the design called for a very long crosshead; it really was a crosshead in those days and not the mere block which is seen in its survivals, as in locomotives, for example. The side rods had to descend at each side of the cylinder, and as the outside dimensions of the cylinder might in the earliest engines be 2ft. or 3ft., and in the later engines with 100in. pistons something over 9ft., the crosshead was of considerable length. It is not surprising to learn that it was the part that failed most frequently, but it could be replaced in a few hours and engineers stated in the evidence before the Committee on the Holyhead road that it was a good thing to have it weak, as its failure saved the cylinder from destruction. In fact, the crosshead was a relief valve which prevented much worse damage if the cylinder, as sometimes happened, took water.

A curious item of history is worth recording, for it illustrates admirably man's inability to bring inventions rapidly to perfection. Before 1818 it was the practice to stop the engines of steamers some distance before they reached the quay and allow them to drift alongside. The story runs—according to Williamson's "Clyde Passenger Steamers"—that in that year young James Watt being on board the "Dumbarton Castle" was told by the engineer that on the preceding evening the vessel had grounded, with the result that the paddle wheels touching the bottom had revolved in the wrong direction and had reversed the engine. Young Watt immediately grasped the significance of this mishap, and taking off his coat demonstrated how the engines could be reversed at will. After that the manœuvring of engines when coming up to moorings became common practice. In the interests of exactitude it ought to be pointed out that a slightly different version of this story with a different date is given by the same historian in another place—his "Memorials of James Watt."

* * * *

We have noted that in the first few years the vessels were designed principally for the passenger trade, but by degrees the carriage of cargoes began to assume importance, and the tramp was coming into existence. It will be interesting to look at some of the engines of this exciting initial period. Amongst the pioneers you will be glad to know that Scotts of Greenock held the leading position. Mr. James Brown, the present managing director of that old firm, has long been a member of our Council, and it is gratifying to us to be able to record the prowess of his company. Another Scottish company which must be mentioned especially is that founded by David Napier. Before his day, all steamers, following the sailing ships of that time, had been built with bluff bows and it is recorded that Napier stood up at the prow of a sailing packet between Glasgow and Belfast in stormy weather observing the action of the bows. Not until a tremendous wave which nearly carried him off his feet had swept the ship from stem to stern was he satisfied that he had pushed his observation to the limit. On his return to Glasgow, he set about making the first model towing experiments on record with the purpose of settling the form of the hull of a very famous little steamer, the "Rob Roy" of 1818. She was eventually purchased by the French and renamed, being, as David Napier himself said, converted with the help of a priest and some holy water from a Scottish freebooter (Rob Roy) into a French monarch "Henri IV." Napier has left a memoir of these experiments which is worth transcribing: "I cannot, at this distance of time, recollect the various improvements, or more correctly the alterations, I made on steamers. I recollect that they were generally built with a full round bow, which, with a clear run, was considered at that time the best shape for speed; but on perusing the works of Bossut, a celebrated French mathematician, on the resistance of fluids, I began to have serious doubts of the full bow being the proper shape, to prove which I set about a series of experiments, for which a large mill-dam that bounded the premises at Camlachie afforded great facilities. Having obtained a block of wood of the proportional length, breadth, and depth, I intended to build the 'Rob Roy,' and having erected a framework close to the water of considerable elevation, at the top of which was a roller or drum for winding up a weight, the other end of the line being attached to the experimental block, I carefully noted the time the weight took to descend, dragging the block at the same time through the water, and continued fining the bow as long as there was any perceptible increase to the speed, always taking care to put the block into the scales each time I altered the shape, so as to keep the weight of the block the same, which block or model I gave to the shipbuilder to take off his lines for build the 'Rob Roy.' When it was launched nautical people said I had put the wrong end foremost; however, when it was tried it was found that they were wrong, and the old boats were put into dock to have their bows sharpened, which was found invariably to increase their speed."

* * * *

You have, without doubt, been able to visualise the remarkable advance in marine engine construction which is illustrated by the engines—still remaining with us—of Bell's "Comet" and Robert Napier's "Leven." That advance was not due to the skill of designers and the requirements of shipowners alone. It could not have been achieved without many contemporary improvements in machine tools and workshop practice. Unfortunately, the vastness of our subject leaves no time to deal with these developments, but if we are to understand the progress of invention aright, we must recognise that collateral advances make it practicable.

With this acknowledgment of the part played by contemporary crafts we pass to a consideration of the development of ships and engines in the second quarter of the nineteenth century. First let us speak of the ships themselves. The use of iron did not begin seriously till the late "'thirties," and up to that time all steamers were built of wood, occasionally plated with iron. The traditions and practice of the old shipwrights were not easily overcome, and it was not

* Excerpts from the Seventh Thomas Lowe Gray Lecture. The Institution of Mechanical Engineers, November 30th.

till the end of the nineteenth century was approaching that scientific design of hulls began to replace traditional method and the personal touch. Sir George Hunter, that great veteran amongst shipbuilders, tells me that in 1860, when he first began work in a shipyard, the shipwright built up a model with successive layers of wood, which he carved away, shaping the ends and lines as he fancied they should be. Then he unscrewed the sections and from them drew the "water lines" from which the rough shape of the wooden frames were derived. But it must not be thought that because the design of hulls was unscientific it was bad. The best shipwrights had a "feeling" for the right form and the wonderful sailing clippers, which sometimes touched 18 knots, show that they occasionally achieved designs which could not be surpassed to this day. The principal part that science plays is that it enables the modern shipbuilder to say before a vessel is laid down what her speed, deadweight, cubic capacity, and so on will be, and what power of engines will be required. The old shipwrights had to depend upon experience and guesswork before William Froude established the laws of ship resistance and introduced the experimental "tank."

If it could be said of shipbuilding and marine engineering that one period was more interesting than another, the palm would have to be given to that which we are now entering—between 1825 and 1850—for to it belong the introduction of iron ships and the coming of the screw propeller. Moreover, towards the end of this period the design and construction of paddle engines departed radically from earlier types. This change was partly due to the increasing size and engine power of ships and partly to improved workshop practice led by such great engineers as Maudslay, the Napiers, Penn, Field, and others whose names will occur to you. As the required power became greater the necessity for compact design increased and the old type of engine with its graceful frame and beams had to make way for a type in which the connecting-rod acted direct on the paddle shaft.

* * * *

THE SCREW PROPELLER.

Of all inventions connected with the propulsion of ships by power none was more momentous than the screw propeller. As with many inventions—the steam turbine is a notable instance—there is no one who can be named definitely as the first inventor. The idea seems to be of great antiquity, and long years before the screw was adopted many propellers had been actually made, and many more had been patented. But if its origin is wrapped in mystery there is no doubt about the man to whom the credit of establishing it belongs. He was not an engineer, but a farmer "out Hendon way," who was fortunate or able enough to secure the co-operation of a banker. In 1835 Francis Pettit Smith—subsequently knighted—secured a patent for a propeller of what we now know to be a very indifferent design. He fitted it to a model which he exhibited in a pond on his farm and in the Adelaide Gallery, London, where the Admiralty inspected it. But the only offer he had for the purchase of his patent was made by the Pasha of Turkey! It was declined. If Smith and his friends were not particularly encouraged by that exotic offer their ardour was not destroyed by the coldness of the Admiralty. They fitted a 6-ton boat with a 6 nominal h.p. engine driving a propeller which had a helix of two complete turns. Often in mechanical engineering an accident has given the clue to an improvement. It did in this case. In February, 1837, Smith's propeller struck an object in the Paddington Canal and part of it was broken off. The vessel immediately went faster. Recognising the cause—which is half the battle in successful invention—Smith immediately put in hand a new propeller with but a single turn. Then, to demonstrate that his invention could be used at sea as well as in a canal, which no one was ready to believe, he sailed in his little vessel from Blackwall to Ramsgate, where, the piously disposed will note as a good omen, he arrived on a Sunday morning almost in time for church. Thence he went on to Dover, Folkestone, and Hythe, covering 5 miles in about three-quarters of an hour. On September 25th, 1837, he set about returning to London and had the excellent good fortune to be overtaken by a sea so stormy and boisterous that it nearly overwhelmed his little ship. I say fortunate, for the eye of the Admiralty was upon him. Naval officers who watched through their telescopes the perilous journey of the little boat reported to Whitehall, and my Lords had to admit themselves impressed by the achievement of the screw-propelled cockle-shell in circumstances which were regarded as wholly unfavourable to that form of propulsion. Smothering their antipathy, they invited Smith to demonstrate his vessel before them. The interview was so far satisfactory that Smith and his friends, taking their courage in both hands, built, for £10,500, the "Archimedes" of 200 tons, fitted with two engines "of the collective power of 80 horses." They expected to get 5 knots out of her; she actually attained over nine. Subsequently, after various mishaps, the "Archimedes" circumnavigated Great Britain and screw propulsion came into its own. "Everywhere," writes John Bourne, "the vessel became an object of wonder and admiration. Heretofore," he continues, "engineers had been almost unanimous in the opinion that a screw would occasion a serious loss of power from the obliquity of its action, and the consequent dispersion of the water; and it was concluded therefore that it would be ineligible as a propeller. But it was impossible to resist facts such as the performance of the 'Archimedes' afforded . . . ." "But," he goes on, "at the outset it was not merely against physical difficulties, but against the universal sentiment of the engineering world, that the authors of the screw propeller had to work in accomplishing its practical introduction. Before these combined impediments countless inventors had succumbed, and it is difficult to overrate the merit of those who, without the consolation of sympathy, and in spite of a scepticism wellnigh universal, preserved their faith unshaken, and laboured steadily onward until their labours, pains, and perils had a final issue in successful achievement." The prosaic world of to-day, whilst endorsing every one of Bourne's noble sentences, will remember that God is on the side of the big battalions and will advise inventors who desire to introduce ideas foreign "to the universal sentiment of the engineering world" first to seek from bankers something more substantial than "the consolations of sympathy."

The success of the "Archimedes" led to immediate important results. Four merchant steamers, one of 1500 tons, were built in 1840–41, and in the latter year H.M.S. "Rattler" of 888 tons burthen was laid down at Sheerness. Immediately after her completion in 1843, the Admiralty started a series of tests which is famous in history, and, being satisfied, ordered no less than twenty vessels to be fitted with propellers.

Such in brief is the history of the introduction of the screw propeller in this country. Contemporaneously, John Ericsson was labouring successfully on the Continent and in America so that the whole world was converted at about the same time. But, once more, the propeller followed the common law of invention. Ship propulsion could not be entirely and at once dissociated from the long-established methods. Hence we find that the value of the screw was not measured on its proper merits alone, but on the fact that sails could be used with it better than with paddles. Indeed, canvas did not wholly surrender its position for many years, even in the Navy, and for a great part of its early life the steam engine was regarded almost as an auxiliary to sails, just as the oil motor is to this day regarded in fishing and yachting fleets. The paddle wheel had manifest defects from this point of view. The propeller had far fewer, and those it was sought to remove by making propellers which could be feathered axially with the keel or even lifted right out of the water.

* * * *

SCREW ENGINES.

It will be seen that by the early 'fifties the major problems of the steamship had been solved and their merits established. In 1843, about thirty years after the "Comet," the number of steamers built was only about 7 per cent. of the total output of the yards. In 1855 there were over 2000 steamers belonging to the British Empire; in 1857 the proportion of *output* had risen to 21·7 per cent. In that year there were 18,429 sailing vessels in the home and foreign trade of this country and 899 steamers. The average number of hands per sailing vessel was 8·2, whereas it reached the astonishing figure of 27·75 in steamers. The proportion of screws to paddles was approximately unity, but the propeller was employed rather as an auxiliary to sails than as the main system of propulsion. Out of a total of 829 screw steamers, 473 were of iron. Many of the screw engines were small. In 1857 228 steamers were built in Great Britain. In paddle steamers at this time the nominal horse-power was about 1 to every 2·8 tons of builders' measurement and the brake horse-power about 1 per ton of displacement.

In the third quarter of the nineteenth century the marine steam engine rapidly acquired a form from which it has not departed materially to this day. In 1860 the horizontal engine was still common, but ten years later it had been entirely displaced by the vertical in the mercantile marine, and in 1875 the Admiralty, overcoming its preference for an engine which could be placed wholly below the water line, came into accord with the mercantile practice of the day.

By far the most important advance was the adoption of the compound engine and the surface condenser. The former was impossible, and the second unnecessary, whilst steam pressures were low, and in this country they remained low—not above 15 lb. to 20 lb. per square inch by gauge—much longer than abroad. On the Continent pressures up to 60 lb. per square inch were being used before 1830 and there are reasons for believing that the first "high- and low pressure marine engines," as they were called, were built and fitted in Holland. They were inclined paddle engines and true predecessors as we have already seen of a pattern which is made to this day.

About 1840 Hall invented the marine surface condenser, but it failed, mainly owing to the difficulty of packing the tubes. Some years later Elder succeeded in combining a surface condenser with a high-and-low pressure engine. The combination was called a compound engine to distinguish it, abroad at least, from a high-and-low pressure engine with a *jet* condenser.

Unfortunately time does not permit a description of the changes in boiler design which led by degrees to the general adoption of higher pressures and the consequent general use of compounding. Nor can we stay to examine the history of the surface condenser which the higher pressure and higher boiler temperatures made essential. What it is necessary for our purpose to observe is that by the 'eighties a definite type of marine engine and condenser had been produced. During the succeeding fifty years or so, improvements in economy were made by tripling and quadrupling, and are still being sought in new valve gears to suit higher steam temperatures and pressures, and in various methods of using up the last few units of heat in the steam. But in essential parts the engine remains what it was fifty years and more ago.

When this state of affairs has been reached it is the proper business of the engineer to break new ground, for there is no other way of escaping from the limitations imposed by the standard design. This happened towards the end of last century when Parsons applied his steam turbine to marine propulsion. It at once opened a new era, the era of the very big ship, but as far as small cargo ships are concerned, it has not made, and is now unlikely to make, any notable difference. What it might have done, after the introduction of gearing, had not the internal combustion engine come upon the scene, no one can say. Probably not a great deal. For the ordinary tramp and smaller merchant steamer the reciprocating steam engine and the internal combustion engine are as much unchallenged as the turbine is in large and very high-speed vessels.

Of the events of this century in marine engineering the rapid progress of the internal combustion engine is by far the most important. For ships of the class with which this lecture is concerned it has made such advances that approximately one-third of all existing vessels of over 100 tons deadweight are now propelled by oil engines and the total tonnage is approaching 10,000,000. At the present time 162 motor ships are being constructed in the world as against 125 steamers. This does not mean that the steam engine has been displaced by a corresponding amount, for it must be remembered that thousands of small vessels which would not have had engines at all are now fitted with motors as auxiliary power. Indeed, in some respects history is repeating itself. Just as in the 'thirties and 'forties the screw driven by a steam engine was an auxiliary to sail, so now is the screw driven by an oil engine. The oil engine is, moreover, making steady progress for the propulsion of larger vessels, and it still has an unknown future, though there is, so far, no trustworthy indication that in single units it will be carried beyond powers in the neighbourhood of 10,000 h.p. at most, and it seems not improbable that smaller units will be generally preferred, even if Mr. Ricardo's revolutionary plan be not accepted.

(To be continued.)

NEW BRISBANE BRIDGE PROJECT.

THE Brisbane River, on which the City of Brisbane is situated, flows in a sinuous course through practically the centre of the Greater Brisbane Area, which has a population of 300,000. Most of the business and commercial buildings of the city are situated on the north side of the river, on which side are also situated many important residential districts. The south side is comprised principally of residential districts, those nearer the city itself being closely built on, while those areas further out are being rapidly occupied. Prior to the opening of the Grey Street Bridge in 1931, the only connection between the north and the south sides of the city (apart from certain ferries) for road traffic was by means of the Victoria Bridge, situated at the southern end of Queen-street.

Prior to 1926, the congestion of traffic on this bridge at peak hours had become so acute that in that year a Commission was appointed by the Brisbane City Council to report on the matter of cross-river traffic facilities. The Commission recommended the construction of a bridge at Grey Street upstream from Victoria Bridge, and another on what is generally called the Kangaroo Point Site, the site being considerably downstream from Victoria Bridge. The Grey Street Bridge was built, but no action was taken with respect to the construction of the second, and greater, bridge.

The Government now proposes to proceed with the construction of a high-level bridge on the Kangaroo Point Site. As there are various wharves above this site used by overseas ships, the river will be crossed by one span of approximately 900ft. with a clearance above high water of approximately 100ft. The width of the bridge has been fixed to provide a 40ft. roadway and two 10ft. footpaths between trusses. The trusses are designed for two 10ft. footpaths on the outside which can be erected at a later date when traffic warrants a 60ft. roadway. The type of design will be a steel cantilever bridge of 924ft. between centre line of piers with approach spans of steel and concrete.

It is expected that the total cost of the structure, together with resumptions and necessary street alterations, will not exceed £1,700,000. When completed, tolls will be collected on the structure, and these will be used to pay interest redemption and maintenance charges. The design of the proposal is being carried out by Dr. J. J. C. Bradfield, well known in connection with the Sydney Harbour Bridge.

DURING the first nine months of this year 1285 aeroplanes were manufactured in the United States, of which 673 were for domestic civil use.

Literature.

Railways and Roads in Pioneer Development Overseas: A Study of their Comparative Economics. By J. EDWIN HOLMSTROM, B.Sc. (Eng.), Ph.D., A.C.G.I., Assoc. M. Inst. C.E., M.I. Struct. E. London: P. S. King and Son, Ltd. 1934. Price 15s.

THIS work will appeal even to the least philosophically minded among engineers and to many who, not being concerned with the subject of which it is a searching study, may find in its pages a large amount of useful data, the application of which to specific minor or partial problems may be considered in the light of the immediately related text. Further, engineers who, in respect of wider issues, are charged with somewhat higher or heavier responsibility, may make similar use of the data and the chapter text, while seeking also to understand in what respects their significance is affected by considerations set forth in other parts of the book. Thus, before an engineer gave his advice or a Minister made a decision involving important works of road or railway construction, this volume might be used in making comparative estimates of costs and benefits.

While the author may reasonably expect that his book will usefully serve such minor purposes, in closely settled countries, as well as in pioneer developments, he has, in pursuit of his main purpose, so presented the subject that the whole policy in regard to railways and roads in countries undergoing early development or as yet undeveloped may be based on rational as well as on economic principles and be swayed by considerations relating to the further as well as to the immediate future, and to the incidental, in addition to the implied, effects of the establishment of any particular system of communications and transport.

The work is in four parts, relating to the problem, rail transport, road transport, and "the choice." In Part I the author analyses transportation systems by relating their economic to their physical structure, and by measuring and correlating the three concepts —consumer's costs, carrier's costs, and virtual costs. He explains that virtual costs are intended to be a statistical estimate of the total wealth absorbed in producing transportation and in causing the indirect benefits that attend such provision; they are "induced currents" caused by the upward flow of wealth through the railway organism.

Discussion of the "anatomy" of transport is followed by a study of its "morphology," data of loads and distances being presented, in respect of transport by porters; pack and draught animals; motor vehicles, including tractor trains; the Diplock Pedrail; the Stronach-Dutton system, and by railways of narrow, medium, and broad gauges. In the chapter on the "physiology" of transport, the author argues that whereas on railways carrier's costs are similar to virtual costs, they are, on roads related to individual vehicle performance.

Part II, Rail Transport, is very ably written and teems with precise data, skilfully employed. The author's method is shown to be one facilitating the correlation of factors of cost, and his discussions are highly practical. The character of the service is, for example, considered in respect of such freight as labourers in batches of ten, sheep, dairy produce, fertilisers, firewood, and palm kernels.

Part III, Road Transport, is a similar study. The data of costs and the types of construction are, of course, too numerous and various to be presented as fully as in the case of railways; but the author has selected suitable examples of typical costs and methods, and usefully discusses basic features of road planning and design, while he makes good use of figures expressing the relations between area, population, and road mileage. He has adapted the standard vehicles' costs figures of the *Commercial Motor* to Colonial conditions in Iowa, Rhodesia, Nigeria, the Gold Coast, for the Kenya and Uganda Railways Road Services, the Uganda P.W.D., and the Uganda Government Transport Services. These data are tabulated on a large folding sheet. In this part, both carriers' and consumers' costs are very fully discussed.

In Part IV the facts relating to railway and to road transport are "refined" and summarised. The *rôle* of the State is discussed, also the geographical and the time "nexus" and indirect benefits. In regard to the proportionate numbers of accidents on railways and on roads, Mr. Holmstrom goes to the root of the matter in a paragraph worth quoting in full.

"Ultimately, the disproportion must be attributed to an extraordinary psychological difference in the public demand for safety on railways and on roads. Whatever the practice on the Continent, no Englishman would seriously suggest removing the footbridge and subways at Clapham Junction and inviting hordes of people, children and all, to stroll at will across the tracks; yet the same thing is taken as a matter of course on every arterial road, traversed by cars running quite as fast and many times as frequently as railway trains, confined to no visible tracks, and driven by persons as to whose skill there is no guarantee whatever." As to the cost of road accidents, Mr. Holmstrom has estimated that at the rate of £4000 for every death and £40 for every injury, the charge per motor vehicle, reckoned on the total number in use, would be, in Great Britain, one-third of a penny per mile run.

It is not necessary to consider whether the problem tackled in this highly informative work could ever be completely and confidently solved. Since Mr. Holmstrom presents the problem as a whole, in its parts, and with a wealth of significant detail, he has provided a very useful aid to wise decisions, while his method, separately considered, does to a large extent bring weights and scales into the argument.

Memories of a Scientific Life. By Sir AMBROSE FLEMING, F.R.S. London: Marshall, Morgan and Scott, Ltd. 1934. Price 5s.

THE author of these "Memories" was born in Lancaster eighty-three years ago. It was his wish at an early age to become an engineer. That, however, could not be managed, as his father was not in a position to meet the expenses of his pupilage. He was, therefore, sent to University College, Gower-street, and devoted himself to science. At the age of twenty-one he secured an appointment as Science Master in a Lancashire school, but after less than a couple of years he returned to London as assistant to Dr. Frankland at the Science Schools, South Kensington. Then he took a post as science teacher in Cheltenham College, which he resigned in 1877—being then in his twenty-sixth year—to enter Cambridge University. In 1881 he became Professor of Physics and Mathematics in University College, Nottingham, and three years later was offered the Chair of Electrical Engineering at University College, London, with which he has retained his association to this day.

In the course of this varied career he met and knew well most of the illustrious scientists of his time, and, besides contributing to the advancement of electricity by his own researches, he closely followed the progress made by others. Many people know Sir Ambrose by his lecturing, an art in which he is unsurpassed, and have marvelled at his gift for condensed, but accurate, descriptions. In these "Memories" that gift is very manifest and very necessary, for it is obvious that the book has been written as much, or even more, for the lay reader as for the scientist. Indeed, the modest price and the whole style give clear indication that the author and the publisher hope to reach the general public. In that hope we join them, and we can assure potential readers that whatever their vocation, they will find much here to interest and entertain them.

Sir Ambrose Fleming's principal work is so well known to most of our readers that it is quite unnecessary to review the pages which he devotes to it, but we may quote one or two short passages from the history of the thermionic valve. Fleming's interest in it began when, in 1885, he observed that the blackening from a carbon filament lamp was not deposited regularly upon the inside of the bulb, but that a white or clear line was left on the glass in the plane of the loop of the filament. Then came the announcement of the "Edison effect," and many experiments, culminating in the discovery that the "space between the filament and the metal plate (now called the anode) sealed into the bulb, is a one-way street for electricity." In 1899 Fleming became connected with Marconi's Wireless Telegraph Company in an advisory capacity, and the problem of rectifying high-frequency currents came before him. "Thinking over the subject," he writes, "I had, in October, 1904, a sudden very happy thought. I recalled to mind my experiments on the 'Edison Effect,' and in particular my observation that the space between an incandescent carbon filament and a cold metal plate in a bulb exhausted of its air had a one-way conductivity for electricity. Then I said to myself, if that is the case, we have here the exact implement required to 'rectify' high-frequency oscillations. I asked my assistant, Mr. G. B. Dyke, to put up the arrangement for creating feeble high-frequency currents in a circuit, and I took out of a cupboard one of my old experimental bulbs. The experiment was at once a great success, and I found I could use a mirror galvanometer," &c. The whole future of broadcasting and wireless telegraphy lay in that simple experiment, for when, three years later, Lee de Forrest added the grid which Fleming seems to have been on the point of discovering at one time, the wireless valve took the form from which it has only varied by accretions and in details since that day.

It is by this discovery that Fleming will be remembered when his lectures and his other work have been forgotten. Brief as it is, we are glad that he himself has written for the general reader an account of how it was made.

SHORT NOTICES.

The Design and Construction of Concrete Roads. By R. A. B. Smith, A.M. Inst. C.E., M.I. Struct. E. London: Concrete Publications, Ltd. 1934. Price 8s. 6d.—The book describes, with discussions and explanations, methods of concrete road construction typical of practice in Great Britain. The author's exposition of design is fairly representative of the views and the field of view of the majority of British highway engineers. Accordingly, the chapter on the preparation of foundations, that on reinforcement, and the appendix in which the theory of stresses in slabs is explained are inadequate in the scientific and logical aspects. Very useful information is given, however, in regard to important features of design, while structural details are explained and described with unusual thoroughness and with the aid of drawings and photographs of outstanding merit. Essential features of construction and the choice, preparation, and testing of materials are duly presented, and procedure is impartially and practically discussed, with the exercise of good judgment as to which points most need elucidation. The book is comprehensive in character, for the author, while giving sufficient space to the subject as entirely covered by the title, has been able to include chapters on road junctions, curves and super-elevation; cement-bound surfaces; maintenance; organisation; cost; accessories. A notable and very valuable feature of the book is the chapter in which are set forth data relating to subsoil, traffic intensity, design, the concrete reinforcement, construction in plan, mixing plant, forms, tampings, curing, number of men employed, rate of progress, and cost—for twenty-two completed roads, each description occupying, on the average, rather more than a page.

Die Casting. By Herbert Chase, M.E. London: Chapman and Hall. 1934. Price 21s. 6d.—There are so few books about die casting that this volume is very welcome, even though it hardly deals at all with one aspect of the subject of particular interest to engineers. It is, in fact, a book for the user and the prospective user, rather than the producer. By copious illustrations it shows the enormous range of products which can be economically made by die casting; discusses the nature of the alloys which should be employed for specified purposes; and gives some advice on design and testing. In all this there is practically nothing about the die-casting machines themselves, but it is interesting to observe the great number of engineering products, even including the bulk of a small screw-cutting lathe, which are now economically produced by this modern method. We notice that nearly all the parts illustrated are made in a zinc alloy—that is, one with a zinc base—and, according to the author, an alloy of that class is used for three-quarters of the total output of die castings. The reason is that zinc alloys are cheap, are better than any other alloys but those on a copper base, cast easily at fairly low temperatures, and will give all the qualities that are expected in die castings. After zinc alloys the author places aluminium alloys, which, of course, have the property of lightness. In other chapters Mr. Chase deals with the Design of Die Castings; Specifications, Inspection, and Tests; and Finishes. This is a thoroughly practical book within the limitations to which we have referred, and we venture to recommend all who are considering the adoption of die castings to take, at least, an opportunity of glancing through its pages.

Highway Engineering: A Textbook for Students of Civil Engineering. By John H. Bateman, M. Am. Soc. C.E. London: Chapman and Hall, Ltd. 1934. Price 25s. —The second edition of this useful text-book, whose author is now engineer-manager of Berrein County (Michigan) Road Commission, includes new chapters on highway traffic, the reconstruction of roads and streets, and stage construction, while the matter relating to bituminous treatment has been expanded. Many of the chapters have been revised and consideration of recent developments included. There may be noted, in that regard, the exposition of super-elevation and the widening of bends, and the explanation of the use of the mud-jack, which seems to be a form of Poulter's mud pump; while the eye of the prospective reader is caught by illustrations such as those of an elevating grader, or grader-loader, a multiple batch lorry, and the Killefer planer. The book will continue to serve as a guide to practice in countries in which large mileages of roads are made and maintained by methods neither practised in Great Britain nor described in insular British works on road engineering. It follows that the volume should be included in lists of books recommended to British students of highway and civil engineering, and be commended generally as a source of information about practice and procedure in the United States.

BOOKS RECEIVED.

Alte Probleme-Neue Lösung in den Exakten Wissenschaften. Leipzig: Franz Deuticke. Price 3·60 m.

Elements of Water Supply Engineering. By E. L. Waterman. London: Chapman and Hall, Ltd., 11, Henrietta-street, W.C.2. Price 21s, 6d. net.

The Internal Combustion Engine. Volume II, *The Aero-engine.* By D. R. Pye. London: The Oxford University Press, Amen House, Warwick-square, E.C.4. Price 21s. net.

Ein Bertrag zur Entwicklung der Kompressorlosen Dieselmotoren. By Dipl.-Ing. P. L'Orange. Berlin: R. C. Schmidt and Co., Lutherstrasse 14, W.62. Price 3·40 rm.

Life and Letters of Sebastian Ziani de Ferranti. By Gertrude Ziani de Ferranti and R. Ince. London: Williams and Norgate, Ltd., 28–30, Little Russell-street, W.C.1. Price 12s. 6d. net.

Bergtechnisches Taschenwörterbuch. Volume 1, *Englisch-Deutsch.* By Professor W. Schulz, Professor Dr. H. Louis, and Bergassessor Goethe. Essen: Verlag Glückauf G.m.b.H. Price 4·20 marks.

Machine Tools from the Works Manager's Point of View.

By JOHN HOLLOWAY, M.I. Mech. E.

No. II.

(*Continued from page 545, November 30th.*)

IT may be argued that a good range of speeds and feeds is of advantage to any class of machine tool, inasmuch that it increases its scope and general utility. That argument held good before the days of specialisation, when practically any job went on to any machine, suitable or otherwise, in an effort to keep the machine occupied. At that time an all-round machine was held to be of great value, and so it was, for it could do a great variety of work and could be kept constantly running, though probably not very efficiently. Such a machine would require to have a wide range of speeds and feeds in order to cover the varying class of work it had to deal with. But all that was in the days of very limited works organisation, when there was little, if any, "planning" of work or setting out of operations before a part to be machined was allocated to any particular tool.

Selecting the Best Machine Tools.

The works manager of any well-organised works in these days is not looking so much for general utility tools as he is for specialised tools. All his work has been, or should have been, well thought out, operation by operation, and the machine in the factory most suitable for the job has been selected beforehand, to say nothing of special small tools, jigs, and fixtures designed to expedite the work. An unduly wide range of speeds and feeds will therefore not prove so attractive now as at one time it did, especially when it comes to considering the enhanced cost of the new machine.

Take, for example, one of the many medium heavy super high-speed lathes shown at the Exhibition. It is a marvel of engineering skill, both in design and craftsmanship. How different it is in general appearance to its pre-1900 prototype. In this respect it may be said to have changed as much as the present streamlined motor car has from the pre-1900 type, and for this the lathe manufacturer is to be congratulated, for he has produced something much more pleasing to the eye and easier to operate. But while all this is perfectly true, it is equally true to say that, in principle, all the old features of the S.S. and S. lathe as we know it still remain. There is the old familiar traversing shaft and leading screw on practically every lathe exhibited, thus retaining them in the category of "general utility machines." In the old days this feature was expected and demanded, but to-day when we see the lathe entirely remodelled, with power, speeds, and feeds vastly increased, quick power motions in every direction, roller and ball bearings fitted, improved lubricating methods adopted, greater strength and rigidity in every part from headstock to tailstock, ball bearing revolving back centres, centralised control, brakes to bring the machine quickly to rest; when we see all this done and remember the object in view has been to take full advantage of the improved cutting tools now available, we may well ask, Should such a lathe be relegated to the category of "general utility machines," and, if so, is the necessarily increased cost of the machine justified? Will the increased output from the improved machine be commensurate with the price?

The presence of the leading screw on these high-powered, super high-speed laths may be regarded by many works managers as somewhat valueless. It appears to be put there from force of habit, or in the expectation of an event. A screw may possibly have to be cut occasionally; hence the leading screw must be provided with all its necessary gears, &c. True, it will probably lie inert for the major part of the time; it may be used perhaps once a month or even once a year. But, whenever it is used, whether it be frequent or otherwise, it will never require anything like the power or the speed provided on the lathe. On the other hand, if screw cutting has to be done so often as to take up a high percentage of the total time, it then becomes an extravagence to use so costly a machine for the purpose, because manifestly when put to that use the lathe is grossly over-motored, while the strength and rigidity of the design is of little advantage, and therefore a less expensive type of machine will do the job equally well. It would appear fairly obvious that what the works manager or production engineer will look for, so far as turning only is required, is a plain high-powered turning lathe suitably equipped with a limited number of speeds and feeds for turning specific specimens of work. He will not want a lathe equipped with a range of speeds and feeds that will be suitable for anything and everything from the size of a pin to that, say, of a heavy oil engine shaft. He will also have to consider how the heavy parts to and from the machine are going to be handled.

Simple and Elaborate Machines.

In all modern well-organised machine shops the work to be done on any particular machine is specific—that is to say, it is "planned," the work does not find its way to the machine in the old haphazard fashion; it therefore follows that the machine also requires to be specific, and able to deal with a given job in the most economical way, both as regards labour and time. Consequently, the machine can be stripped of all unnecessary refinements, bringing the initial cost to a level that will prove attractive.

This series of articles is not dealing so much with factories producing motor car engines and other parts as with works and factories producing medium and heavy units, such as steam or oil engines, air compressors, pumps, machine tools, or textile machinery. In the motor car industry all parts can be and are produced on the grand scale, where it well pays to have single-purpose and special-purpose machines and tools. It is recognised that the heavier industries are not so favourably placed in this respect; at the same time, we know of many works where units are put through the shops in batches, the quantity in the batch varying according to the anticipated demand, the number put in hand at one time is in many works as low as six, while in marine shops parts have frequently to go through in single units.

It may well be considered by many an open question as to whether special-purpose machines could be justified in the cases referred to above; naturally, each case requires to be considered according to the conditions obtaining in that particular works, but it is a demonstrated fact that "Planning" work pays handsomely, whether the quantity be great or small, and the point is that where work is planned in advance, the most suitable machine is selected for the job; now the ultimate cost of the job is:—Material, plus wages, plus on-cost, or overheads, and the latter, *i.e.*, overheads, are vital; these vary enormously in different works, depending on the many factors which have to be taken into account. But there is one factor which every works of any note has to take seriously into account, and that is upkeep and depreciation of the plant, special tools, jigs, and fixtures. It therefore follows that the initial cost of the machine, quite apart from the capital expenditure, will influence the ultimate cost of the job very appreciably, so that if the work can be carried out expeditiously on a simple, inexpensive machine, the cost will be lower than if done on a more expensive and elaborate machine.

Taking an all-round view of the machines exhibited one is forced to the conclusion that the tendency of modern design is in the direction of elaboration; this is equally true of the British, American, or Continental designs. British makers are not a bit behind their foreign competitors in cleverness of design and means for manipulation, and the user has no longer any need to look abroad for progress in this direction. All this is excellent in its way, but the experienced works manager may be pardoned if, when he returned to the works after visiting Olympia, he began to wonder if cleverness had begun to take the place of soundness in machine construction. After all, an exhibition is a somewhat hectic place compared with the more serious atmosphere of the every-day workshop; the finer points of a machine can be shown to advantage in the exhibition, it can be put through all manner of gymnastics and perform many quite wonderful tricks. One machine in particular comes to mind—a universal milling machine. By the simple manipulation of a lever or two every part seemed suddenly to become alive, every part that could move did move, either fast or slow, just as the operator desired. No one will be inclined to cavil at such a machine, it is really a very fine performance, and one can easily appreciate the amount of thought and work that has been put into such a mechanism. It is essentially a tool for the the tool-room, where, no doubt, it will find a place; but, at the same time, one is left with the conviction that seldom, if ever, in the workshop, will every motion be used to very much advantage. Then, again, comes the question of initial cost, to which must be added upkeep and depreciation.

To emphasise the point further, such a machine as described above would cost easily twice as much as a medium good-class miller of the same capacity. Let us suppose the highly developed machine is put to work alongside the medium-class tool on similar jobs. The chances are, indeed, it is highly probable, that at the end of the day both machines will have produced substantially an equal amount of work; but the ultimate cost, taking everything into account, will not be equal, because, though material and wages may be exactly the same, the overheads on the more expensive machine will be higher. That much, of course, is quite obvious, but it should be equally obvious that to put any fitting or adjunct on any machine that is not, or very seldom can be, used, is an extravagance that has to be paid for. The fact is that in the endeavour to save split seconds, a machine may be made over elaborate and too costly a luxury for the ordinary engineering works, as distinct from the mass-production factories.

Absence of Handling Facilities.

It has been stated that in developing the modern machine tool no thought has been given to the problem of handling the work on heavy or medium heavy machines; at least there is no tangible proof of such thought, excepting in one or two special cases. It may be contended that handling the work is not the machine tool makers' problem, but that it is up to the works manager to solve it by calling in the crane or lift maker. Such a contention may be conceded, as hitherto the machine maker has not been asked to provide handling facilities, but then they do not as a rule wait to be asked for developments, and here is a problem in many machine shops waiting to be solved. We suggest that the machine maker should tackle this problem forthwith, for it can be made well worth while and would be certain to appeal strongly to the user.

In most works only a very limited number of overhead cranes and runways can be installed with advantage, for if there are too many they overlap and hamper movement; every machine dealing with work weighing more than, say, 35 lb. or 40 lb. requires handling facilities, as otherwise most, and sometimes all, the time saved by high-powered fast-cutting machines is lost in getting the work off and on the machine.

All tools coming within the category of heavy machines are now supplied with their own motors, and this surely simplifies the problem. Here is power in plenty to handle the heavy parts coming off and going on to the machine, but it needs applying; moderate-sized planers, milling, boring, and shaping machines will no doubt be best served with a form of electric jib crane, taking the power from the motor on the machine; the heavy planers and borers will demand the attention of the heavy overhead cranes, which, being freed from attending the lighter class of machine, will be able to give undivided attention to the heavy class.

For the medium-sized lathes the problem is perhaps simpler, that is, for ordinary turned work; this being round in form only requires to be lifted clear of the slide rest and lowered on to a trolley or rolled clear of the machine. The ease with which round work can be handled was shown during the war, when women and girls were machining heavy shell, the total weight handled by each girl per day amounting to several tons, but they never realised what the weight was. The writer originated the bench serving system, on which the shells were rolled to their respective machines, and then by means of a light portable bridge piece the heavy shells were again rolled from the bench right on to the machine. After the operation had been carried out the shell was again rolled over the bridge piece back to the bench; the machining operation each girl did was so short that some quick means of handling had to be found, and overhead runways or cranes were out of the question. This application is only mentioned here as an instance of how work can be quickly handled when it has been carefully arranged for.

By the use of improved cutting tools machining operations on modern machines are being reduced to such an extent that quick handling methods have become a necessity and must receive attention. The lifting tackle should be incorporated in the machine design, just as quick power motions have been incorporated; the symmetry of the machine will not then be disturbed, but its usefulness will be greatly increased and justify the present high capital expenditure. To reach a satisfactory solution of this question of handling it may be that the machine manufacturer and the crane maker will collaborate to bring it to a successful issue, but whichever way it is done, no time should be lost in setting about it.

The selection of, and the addition to, a machine shop plant always call for careful consideration; the aim is to install a well-balanced plant, so that all the machining operations on all the parts that go to make a complete unit of production are carried out as far as possible in unison; if the plant is out of balance some components are finished long before others. In some works this result appears to be expected; hence large finished part stores are provided, where the components finished in advance can be stored until the others come along. There are, of course, various factors that may upset the balance, but all the same, the aim should be to select machines for given purposes and of known output to ensure as far as possible an even flow of all the parts required for the unit. This is one direction in which exhibitions are useful to the works manager; they could be made much more useful and no doubt in course of time they will be; but, taken as they are, they give the works manager the opportunity of seeing at first hand the general trend of development in machines, and at the same time help him to determine the type of tool that would be of greatest advantage to have in his shop; he will probably know beforehand what is required to balance his plant and will make his selection accordingly. Likewise, some part of the works production may be too costly, either because of the operations required or because it lags behind and

holds up the completion of the unit. With this definite information in mind a wise purchase can be made which will result in greater economy.

One of the most difficult things to ascertain is what is likely to be the nature of future developments in machine tools. Already we see hydraulic power replacing mechanical power in quite a number of machines, and the question as to how far this is likely to go is of great interest and importance.

(To be continued.)

The Vertical Cross Tube Boiler.

By A. L. HAAS, M.I. Mech. E.

LIKE the Lancashire, the vertical cross tube is a peculiarly British design, and although the subject of much criticism, it continues to be manufactured and sold in response to a demand for an economical and convenient means of raising limited quantities of steam. Such boilers require no special setting, can be dumped in any convenient corner, and will give a long term of satisfactory service under treatment which would incapacitate many other kinds of boilers.

Comparative fuel economy is largely dependent upon evaporation and, under easy steaming conditions, there is little to choose between the vertical cross tube boiler and its rivals. The case is, however, altered if the boilers are forced to maximum evaporation. There is a dearth of information as to evaporation tests on vertical cross tube boilers, but under such tests, neglecting fuel economy, an evaporation of 12 lb. per square foot of heating surface has been obtained. Such a rate of evaporation means deliberate wastage of fuel, but it is here recorded as a fact within the writer's personal experience.

There is no recognised evaporation rating for vertical cross tube boilers, and makers' views differ considerably on the subject. From extended experience with the best available coal the maximum evaporation rating should not exceed 10 lb. per square foot of submerged heating surface and 100 lb. per square foot of grate area. The foregoing is based on Welsh coal of not less than 14,000 B.Th.U. per lb. With inferior fuels these figures require proportionate adjustment. In this country it is generally unsafe to count on more than 12,500 B.Th.U. per lb. of coal, which means a rating of 8 lb. per square foot heating surface and 80 lb. per square foot of grate area. When such boilers are for export overseas, it is wise to ascertain the thermal value of the available fuel. Certain Indian coals are as low as 9000 B.Th.U. per lb., and rated evaporation per square foot of heating surface and per square foot of grate area must be reduced accordingly.

Low-grade fuels are normally high in ash and a high percentage of ash reduces effective thermal value below bomb calorimeter determination, as the heat in the carbonaceous fuel is partially expended in raising the ash to combustion temperature. In a low-grade Indian coal of 9000 B.Th.U., with 20 per cent. ash, it is desirable to calculate on 8000 B.Th.U. per lb. of fuel.

Under the above maximum evaporation rating a vertical cross tube boiler will give 60 per cent. efficiency in terms of fuel; with best Welsh coal, 8 lb. of water should be evaporated per lb. of fuel from and at 212 deg. in a new clean boiler. On the same basis with feed water at 60 deg. Fah. and 100 lb. working pressure 7 lb. of water should be evaporated, and with 12,500 B.Th.U. fuel, 6 lb. If the boiler is unlagged, exposed to the elements, or in need of internal cleaning, 5 lb. of water per 1 lb. of 12,500 B.Th.U. fuel, with feed water at 60 deg. Fah. and 100 lb. pressure, should be assumed. Taking all circumstances into review, it is unsafe to guarantee greater fuel economy under normal daily operation.

It will be noted that heating surface as such is an incorrect basis for assessing total evaporation; grate area is equally important. The trouble with inferior fuels is to burn sufficient in a boiler of normal design, and for export it would seem desirable to modify the proportions of diameter to height, increasing the diameter of the boiler to allow, say, 25 per cent. greater grate area. As considerable numbers of vertical cross tube boilers are exported to India, this suggestion might be considered by makers in this country.

Connected with this matter of fuel is that of draught and furnace fittings. Inferior fuel of high ash content requires wider spaces between fire bars. It should not be necessary to point out that to starve a boiler of air reduces efficiency and limits evaporation; but vertical cross tube boilers in a temporary location are usually supported on a flat surface, the lowermost edge of the outer shell plate forming a skirt, and the space below fire bar level forming the ashpit. A gap in the front of the skirt fitted with a removable damper gives air and ash access and a means of checking the draught. The ashpit gap is usually too small, and could be increased by 50 per cent. with advantage. If combustion is retarded by lack of air (a not uncommon complaint), the boiler should be raised on wedges or blocks to effect a cure.

It is usual to provide this type of boiler with a short self-supporting steel chimney, generally 6ft. or 8ft. in length, and this is usually sufficient in the case of first-class fuel, as the induced draught is negligible and forcing is undesirable. With inferior fuel of high ash content difficulty is experienced in getting effective combustion and the provision of a chimney of greater length may be essential. With Indian coal steel chimneys 20ft. to 30ft. high, guyed for support, may be essential.

Comparative construction and design of vertical cross tube boilers has considerable interest for those who must perforce specify or select such boilers for given conditions or duties. It is essential, first of all, to consider whether the cheapest procurable boiler is required. If so, any invitation to quote can confine itself to a statement of the desired evaporation and size, leaving the makers entirely free, except for any local statutory restrictions if for export and for the conditions imposed by the company with which it is proposed to insure the boiler. Such a boiler will have parallel fire-box and horizontal cross tubes, and be provided with the cheapest procurable mountings.

Assuming, however, that while a good boiler is required, price is a consideration, it is desirable to make certain stipulations in the inquiry, and the following notes should be of service in framing the inquiry and adjudicating on the offers received.

A taper fire-box and inclined cross tubes are preferable for reasons of good circulation. The external shell should be butt-jointed with double cover straps. Where two belts of plate form the outer shell, the circumferential seam should be out of line with the fire-box crown seam. While it is usual to dish both shell and fire-box crowns, it is preferable that one crown (shell) should be flat. This allows the crowns to breathe and prevents grooving at the base of the uptake.

It is now the general practice to weld the vertical fire-box seam, and so avoid burning of rivet heads and the interposition of a double thickness of plate between flame and water. While smith lap-welding is the best form of weld, electric metallic arc autogenous welding carefully done with both sides of the plate bevelled is equally acceptable. Gas welding of this seam is not recommended.

There is an increasing tendency which deserves encouragement to make the cross tubes from solid drawn hot finish tubing. However carefully smithed, a welded flanged cross tube before placing is a rather pitiful object and hot finish weldless tubing gives an intrinsically better job. There exists discrepancy of opinion as to the merits of flanges and welded-in cross tubes; the latter are, of course, cheaper. Unless the flanging is a first-class job, rust separation sufficient to loosen the rivets may occur after long service, and satisfactory repair of this defect is nearly impossible. Moreover, there is the drawback of two thickness of plate to impair heat transmission. Provided welding is carefully done by electric metallic arc from both sides of the fire-box, the openings in which have been previously bevelled on both sides, welded-in cross tubes are now advocated in responsible quarters.

The uptake being a plain cylinder riveted to a "bunged out" flange in shell and fire-box crowns, is now usually a short piece of hot finish weldless tubing. To minimise plate wastage it is most desirable to fit an inner cast iron replaceable tubular liner to the uptake.

Opinions differ as to the comparative merits of solid foundation and fire hole rings and outward O G flanging of the fire-box. Solid foundation rings are more expensive, but may involve rivets of abnormal length, and as caulking is possible on one side only, the resultant seams may not be tight. In the larger boilers, fitted with solid foundation rings, it is usual to flange part-way to reduce the length of the rivets. O G flanging if carefully and properly done without an interposed solid ring, gives satisfactory service, but many authorities regard simple flanging at this point as inferior construction.

It is desirable to point out that absolute minimum plate thickness to give the usual factor of safety of 4 is undesirable as reduction of working pressure due to plate wastage may be necessary after short service. The extra cost of 10 per cent. or 15 per cent. increase in plate thickness is the simple cost of the plate at the rate per ton for plates; it is not *pro rata* to the deadweight cost of the boiler. An increase in the factor of safety from 4 to 5 is advised in the case of new vertical cross tube boilers exposed to the elements and using indifferent feed water. Another matter is that a pressed plate manhole door and frame is worth its cost, and that a hand hole door at each end of each cross tube ensures thorough cleaning and scaling of the cross tubes. From experience such provision may be considered a necessity and not a refinement, although few commercial cross tube boilers are so fitted. Sludge hand holes just above the foundation seam are taken for granted, but, within reason, the larger and more numerous such hand holes, the better.

A refinement once proposed was to fit a solid drawn coil inside the uptake to dry the steam on its road from the stop valve to the delivery point, but the writer has no first-hand experience of such a fitting, which *prima facie* has much to be said in its favour. With certain feed waters and under heavy steaming, priming may cause difficulties. Hence it is desirable that the stop valve opening inside the boiler should be shielded. A perforated dry pipe or a simple disc of thin plate will reduce the tendency for water to be carried over.

MOUNTINGS.

Unfortunately, the mountings fitted to many commercial cross tube boilers are cheap and very nasty. First-class mountings will equal the cost of the unmounted boiler, and the worst procurable will add 33⅓ per cent. to the cost of the unmounted boiler. It is for the purchaser to decide whether he is prepared to pay for first-class, medium, or merchant mountings. It is assumed that no purchaser would willingly stipulate mountings to be the worst procurable, but the badness of certain alleged mountings which have come under the notice of the writer need to be seen to be believed.

Reference to the catalogues of specialist makers of boiler mountings will show great disparity in type, design, and cost, but it is doubtful if the worst procurable are ever catalogued. Unless the purchaser selects his own mountings by reference to a specialist catalogue—makers of such mountings are most willing to advise—it is usual to stipulate substantial mountings. The term "substantial" in this connection is very elastic, and depends upon the conscience of the supplier. A drawing of a 2in. check valve less than $\frac{3}{16}$in. thick in the neck made of poor brass has been claimed as "substantial" by its maker.

It is usual practice for the boilermaker, if not otherwise instructed, to make his own stop and safety valves and to procure the remainder from a specialist maker. If the purchaser of the boiler cuts down the price, it is obvious that the easiest course open to the boilermaker is to cut down the cost of the mountings.

The most important mounting is the safety valve, the first requisite of which is that it shall be safe and shall be of sufficient area to confine possible rise in pressure to 10 per cent. over the working pressure with full firing and feed shut off. No safety valve yet invented operates until the pressure in the boiler rises above the rated working pressure. Any safety valve should open under a pressure of 5 lb. over, and close promptly at 3 lb. under, working pressure. The area of the safety valves should be proportioned to the maximum total evaporation of the boiler. As vertical cross tube boilers have a high rate of evaporation per square foot of heating surface, the old B.O.T. rule based on fire-grate area $\frac{G A \times 37 \cdot 5}{W P + 15}$ gives a more appropriate area than the latter B.O.T. rule, which was based on a maximum evaporation of 6 lb. per square foot of heating surface, for a vertical cross tube will under certain circumstances evaporate 12 lb. per square foot of heating surface. The latest B.O.T. safety valve rule is based simply on total evaporation, and can be applied directly to the 10 lb. evaporation per square foot heating surface rating.

It should be remembered that the B.O.T. safety valve rules are intended to apply only to marine type safety valves of approved design, in which each valve is independently seated by a multiple coil compression spring, such valves having flat seats and reaction lips to seat and valve. The omission of reaction lips diminishes the lift of the valve and a mitre seat for obvious reasons does not give the same clear aperture relative to lift as a flat seat.

A double Ramsbottom valve with one tension spring with flat seats and reaction lips should be 25 per cent. greater in area than required by the B.O.T. grate area rule, and a similar valve with mitre valve and seat without reaction lips should be at least 50 per cent. greater in area than required by the B.O.T. grate area rule. Ramsbottom valves are commonly fitted to vertical cross tube boilers, and in too many instances the spring fitted is insensitive, owing to an insufficient number of coils in the spring. Five coils is the least number desirable, and such valves should preferably be fitted with seven coil springs.

Good stop, feed check, and blow-down valves are worth their cost, to say nothing as to substantial water gauges. There is discrepancy of opinion as to the relative merits of central stem and wing valves in the case of stop valves and feed checks. In all cases the guide and part guided should be of equal length, and there is reason to consider wing valves preferable.

Blow-down valves should be asbestos packed, *i.e.*, the rubbing surface of the plug should bear on asbestos, not on metal, and a spanner guard and special spanner are essential. Water gauges cocks should be similarly asbestos packed. The reflex type of gauge is preferable to the tubular and, although more expensive in the first place, there is virtually no further expense for renewals. Tubular water gauges require a protecting guard.

The material of the mountings is as important as weight and design. Cast iron and cast steel should comply with some recognised standard specification, and "yellow" metal should be some recognised bronze (not brass). Admiralty gun-metal (so termed) is a good selection.

With the exception of water gauges and pressure gauge syphons, all mountings should be flanged. The screw tails of water gauges and pressure gauge syphons should be provided with an internal back nut. Screw tail stop, check, safety, and blow-down valves should rightly be prohibited by law under penalty. The best method of attachment is by forged steel pads which carry the joint surfaces clear of the lagging, provide flat jointing surfaces and prevent plate wastage through leaky joints. Such pads should not be less than 1in. thick at any point, be soundly riveted to the boiler, and be drop tight. It is preferable that the studs securing mountings should not be less than §in. in diameter, of good wrought iron, which has greater resistance to corrosion and is less liable to break off short under fatigue or by an accidental blow than steel.

FEED.

While not usually considered an integral part of the boiler, the means of feed call for notice. In vertical cross tube boilers, either a small independent duplex pump or an injector, or both, or two injectors are fitted; a dual means of boiler feed is of importance in the case of an isolated boiler. The steam consumption of these auxiliaries should be taken into account in assessing the total evaporation, which should be reduced at least 5 per cent. for this reason. It is usual in the case of a duplex pump to lead the exhaust to a feed tank or, in addition or alternatively, to a steam jet in the boiler chimney. Small duplex pumps are by no means economical, and 50 lb. of steam per water horse-power is not unknown. It is difficult to obtain data as to the steam consumption of commercial injectors, but relatively to water horse-power these are probably on a parity with duplex pumps. The heat in the steam used in an injector is, however, returned to the boiler, as it is from a pump when the exhaust is led to the feed tank. Provisions of boiler feed greatly in excess of maximum evaporation rate are usual as a means to check pressure rise at need and to ensure that rate of feed is adequate.

A feed pump can, of course, be slowed down to balance actual evaporation and keep a steady level in the water gauge by due adjustment, but an injector cannot be so adjusted. If, therefore, the injector is too large it means allowing the water level to fall to the bottom of the glass, and then injecting a full glass of water and repeating the performance when the water level has reached the bottom of the glass again. Where two injectors are fitted, they can either be each just capable of continuous service under easy steaming conditions, or one can be of this size and the other somewhat larger. If pump and injector are fitted, it will invariably be found that the pump is used in preference to the injector as adjustment to varying evaporation is easier. Continuous slow feed leads to regular working pressure and economy of fuel.

COST.

It will be evident that there is considerable difference in cost open to the purchaser of a vertical cross tube boiler. Circumstances must dictate whether the best procurable is warranted; the worst procurable is certainly not advised. It is hoped that the foregoing brief survey may be of assistance in guiding a prospective purchaser in the selection of a vertical cross tube boiler appropriate to the desired duty and of the quality required.

Obituary.

DR. CARL SULZER.

MANY engineers, both in this country and on the Continent, will learn with deep regret of the recent death on October 30th, of Dr. Carl Sulzer, the chairman of Gebrüder Sulzer A.G., of Winterthur.

Dr. Sulzer, who was in his seventieth year, was the eldest son of that distinguished engineer, Mr. Henry Sulzer, and after practical training in the Winterthur workshops, studied in Lausanne and up to 1889 in Dresden under Zeuner and Lewicki. A short period in Sulzers' designing office was followed by a visit to America, where he was employed in the Brown and Sharpe works. Upon his return to Switzerland in 1891 he looked after designing of workshop equipment and machine tools in the Winterthur works, the rapid development of which necessitated the installation of specialised tool equipment.

In 1895 he became a partner in the business, and had a considerable share in the management of the steam engine branch and in the evolution of large units for direct coupling to electric generators, and the development of the uniflow design. He further took a very prominent part in the design and manufacture of steam boilers and such related specialities as high-pressure pipe lines for hydraulic power stations, pressure vessels, gasholders, &c., in this respect closely following in the footsteps of his father who had devoted considerable attention to such developments. The introduction of the valve type water level indicator, which eventually became standard, was also due to him.

At his instigation extensive scientific tests were made on riveting, and he was largely responsible for the general adoption of the corrugated Fox flue for Cornish and Lancashire boilers, and the efficient arrangement of superheaters, the advantages of which had been recognised by his firm as early as 1860, when Mr. Charles Brown was its chief engineer. Ever-increasing steam pressures led to the manufacture of the vertical single and double-bank straight-tube boiler which was taken up on Dr. Sulzer's advice after exhaustive tests in 1890, and later, under his guidance, a boiler of 1500 lb. per square inch pressure—described in THE ENGINEER of December 31st, 1926—was designed, from which the present Sulzer mono-tube steam generator was evolved. In all these specialities his attention was mainly directed to ensuring first-class workmanship and proper treatment of the materials used. Dr. Sulzer also took a keen interest in the development of the centrifugal pump for irrigation purposes. In recognition of his work, the Swiss Technical University in Zurich conferred on Dr. Sulzer the degree of "Dr. Ing. h.c." His achievements in the field of engineering were also recognised outside his own country, and on the occasion of its seventy-fifth anniversary the V.D.I. awarded him the Grasshof Medal "in thankful recognition of his technical and scientific co-operative work and the advancement of collaboration between engineers throughout the world."

When in 1914 the Sulzer undertaking was converted into a limited company, Dr. Sulzer became its chairman, and, leaving the technical side of the business more in younger hands, he devoted much of his time to social and political duties for his country.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

UNIVERSITY DEGREES IN ENGINEERING.

SIR,—I was interested by the letter of "One of Those Despised Evening Students." From my own experience I am able to confirm that an immense capacity for hard work and concentration is essential to any man who intends to study after working hours for a London University degree in engineering. For this reason alone, the holder of a degree obtained as an external student should in most cases be more useful to an employer than a young man who, after leaving school, proceeds to a university, devotes his entire time to absorbing sufficient knowledge to enable him to graduate, then arranges, usually by payment of a premium, to obtain a year or two of very sketchy practical experience in an engineering works, and finally enters the market at the age of twenty-three or twenty-four, in competition with men of the same age who already have seven or eight years' practical experience behind them, and equal, if not better, academic qualifications. This proposition would appear to be self-evident, yet, curiously enough, most employers seem unable to discriminate between the two types of graduate, and, indeed, more often than not, prefer an internal student, apparently placing a greater value upon the 'varsity manner than upon practical experience, other things being equal.

Your correspondent forgets to mention the part played by luck or influence in his successful career. If ability and a capacity for hard work and leadership are the only essentials, I am unable to explain why, with fourteen years' practical experience, a B.Sc. (Eng.) degree obtained as an external student, and a fluency in French and German, I should have had to pass through a period of twenty-seven months' unemployment, and finally return to the drawing board with little or no prospects of bettering myself.

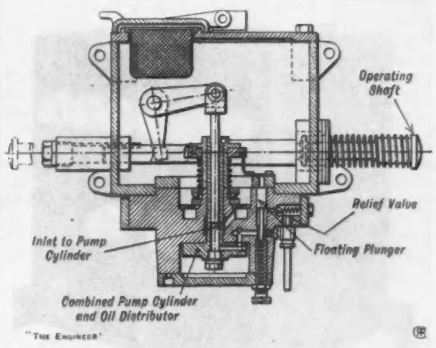
F. H.

Shrewsbury, December 3rd.

THE powers of the Board of Trade, now administered by the Ministry of Transport, as to the safety of railways were originally given in 1840 and slightly enlarged in 1842. The Acts in question had the weakness that whilst accidents had to be reported by the companies, the Board of Trade inspecting officers, though they inquired into the more serious cases, had no statutory power to do so. Their reports, further, were not made public except when briefly summarised in the annual accident report. The Devonshire Royal Commission of 1865 recommended full publicity, and the Act of 1871 thereupon further enlarged the classes of accidents to be reported, legalised the inquiries by the inspecting officers, and authorised the publication of their reports in such a manner as the Board of Trade thought expedient. The same Act also extended the powers, as to inspecting new railways, to alterations to, and additions in, existing railways. The latter had an effect which may now opportunely be referred to. In the year 1858 the Board of Trade issued a circular in which it was observed that considerable inconvenience and expense were caused to railway companies by their engineers not knowing what conditions had to be met in order that the inspecting officers could report that the railway, that was being offered for inspection, could be opened without danger to the public using the same. There was, therefore, enclosed with the circular a list of the principal requirements that had to be complied with. That was the origin of the Board of Trade Requirements for New Railways. Further lists were issued in 1859, 1860, 1862, 1867, 1872, and 1874. The last, which was dated November, 1874—sixty years ago—was amended extensively in view of the Norwich collision of September 10th of that year.

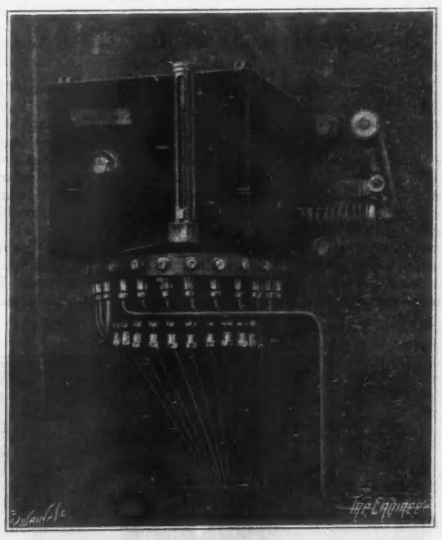
A Mechanical Lubricator.

RECENTLY the firm of David Brown and Sons (Hudd.), Ltd., brought out the mechanical lubricator illustrated by a tone and a line engraving on this page. It is of the multiple delivery forced feed type, and will supply lubricant to any reasonable number of feed pipes. Standard sizes make provision for six, eight, twelve, and twenty-four feeds. The device is operated by an axially movable rod, which can be driven in any convenient manner, such as by a cam or a rocking lever. One arm of a bell crank lever mounted on a cross shaft engages with a slot in the actuating rod and its other arm gives vertical reciprocating motion to the pump plunger. The phosphor bronze pump cylinder is rotatably mounted. At its lower end it



SECTION THROUGH LUBRICATOR

is formed as a distributing disc, the upper surface of which is machined and makes contact with the underside of the lubricant reservoir. The cylinder and disc are held in position by a spring acting through a thrust ball bearing on the bottom of the reservoir. Communication between the pump cylinder and the series of passages leading to the various supply pipes is provided by a radial hole in the distributor disc. At the beginning of each inward motion of the operating rod a ratchet mechanism on the upper part of the cylinder causes the distributor to rotate one "step." Since the slot in the operating rod actuating the bell crank lever allows for a certain degree of lost motion, this rotation of the distributor occurs before the plunger is forced down. On the motion of the plunger, lubricant is forced through a regulating valve and a non-return ball valve to one of the supply pipes. The amount of lubricant supplied to each pipe is adjusted by the regulating valve, which consists of a floating plunger, the movements of which are limited by an adjusting screw. Lubricant cannot



EXTERNAL APPEARANCE OF LUBRICATOR

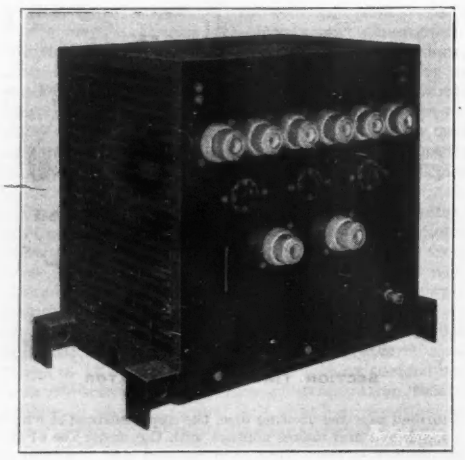
reach the supply pipe until this floating plunger has been driven to the highest point in its cylinder. Thus, if the adjusting screw is so set that the volume swept by the floating plunger is greater than that of the main pump plunger, no lubricant will find its way into the pipe. On the return stroke of the main plunger the lubricant will be drawn back into the main cylinder, and the floating plunger will fall back on to the adjusting screw. Obviously at intermediate positions of the adjusting screw varying amounts of lubricant will be delivered to the pipe. Lubricant from the main reservoir gains access to the pump cylinder through a filter, and is drawn in on the return stroke. The generally neat appearance of the device can be seen from the tone engraving.

Rectifiers for Charging Miners' Hand-Lamp Batteries.

FOR charging miners' hand lamp batteries from A.C. mains Philips Industrial, Ltd., of 145, Charing Cross-road, has introduced the new rectifier shown in the accompanying illustration. The oxide cathode system of rectification is employed and by connecting the cells in banks containing a large number in series, a high overall efficiency is secured, as the higher the effective D.C. output, the less is the proportion of the voltage drop in the rectifying

tubes. When a three-phase, four-wire system is available, an additional increase in efficiency is obtained by dispensing with the mains transformer. To gain the maximum benefit from this system the number of series-connected cells in each bank should be chosen in relation to the main's supply voltage, and with a 230–400-volt system banks of approximately eighty lead cells will give an efficiency of from 75–80 per cent.

The rectifier illustrated has two output circuits, each suitable for charging banks of eighty cells at 5 ampères, and each is supplied by a three-anode rectifying valve. As the charging current is controlled by special lamps or "barretters," no attention is required, as an approximately constant charging rate is maintained irrespective of variations in the cell voltage. A certain amount of variation in the number of cells connected in each circuit is also permissible without adjustment. As the charging rate per bank can be fixed at almost any desired value, and as a greater number of cells can be charged by extending the number of circuits, these charging equipments can be constructed to meet a wide range of requirements. When circumstances compel the use of a smaller number of cells per bank, the usual practice is to employ a step-down transformer, and by using several tappings controlled by a switch, large variations in the number of cells to be economically charged can readily be arranged for. The chargers are made for use on single-phase or three-phase circuits and for specified outputs.

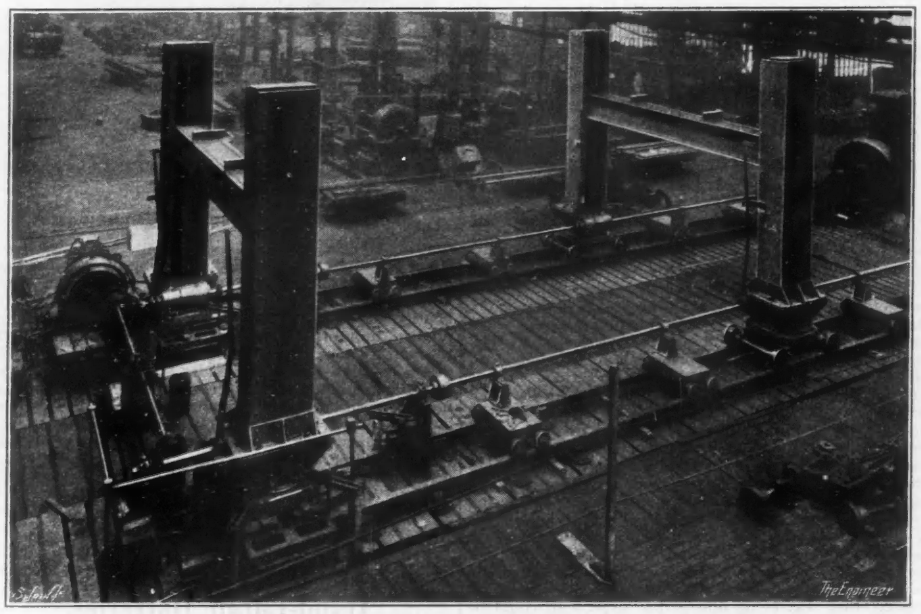


RECTIFIER FOR CHARGING HANDLAMP BATTERIES

Locomotive Jack for China.

THE accompanying engraving shows an electrically driven 125-ton locomotive jack, one of six which have recently been supplied by Tangyes, Ltd., of Birmingham, to the Nanking Railway, China. These jacks have been specially designed for wheeling and unwheeling locomotives in the sheds. Each hoist consists of one pair of stationary and one pair of movable screw jacks. The stationary jacks will be bolted to a foundation while the movable jacks are mounted on a special design of carrier which provides a rigid support when under load. The lifting beams when down fall into slots in the track and have rail sections on them, which coincide with the track to enable locomotives to be driven over them. These beams can be adjusted under the tail bar and bumper beam of the engine, and the engine lifted clear off the track. As will be seen from the photograph, the whole hoist forms a neat and simple construction. Four work-operated screws are all connected up by shafting to an electric motor, and the power is transmitted through a set of bevel gears at each side of the drive. The bevel wheels with shafts are carried by cast iron plummer blocks. Each screw with its worm and wheel is mounted in a cast iron casing, the thrust of the worm being taken on a ball bearing at each end, whilst the load thrust is taken on a larger ball bearing. The square threaded screws are fitted with deep gun-metal nuts mounted in crossheads.

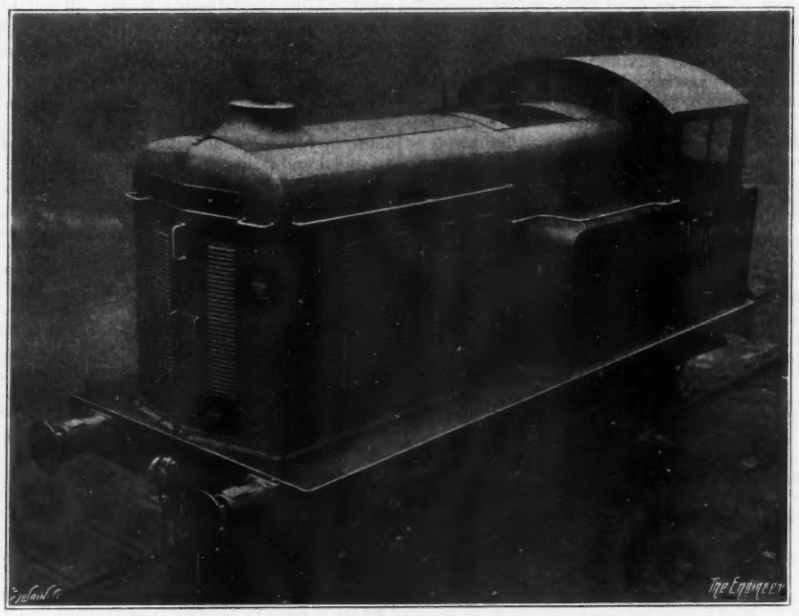
Besides operating the jacks, the electric motor also drives a geared winch for hauling the locomotives into position. The approximate speed of lift of the jacks is 18in. a minute and each jack can be operated independently of the others by means of a dog clutch.



LOCOMOTIVE JACK FOR CHINA

Shunting Locomotive for L.M.S. Railway.

THERE has recently been completed at the Belfast works of Harland and Wolff, Ltd., an oil shunting locomotive for the L.M.S. Railway. The locomotive, which has a total weight of approximately 27¼ tons, is of the six-wheel rigid-frame type, and as all three axles are coupled, the whole of the weight is available for adhesion. It is designed for control by one man and has the normal driver's cab with duplicate controls for easy operation from either side.



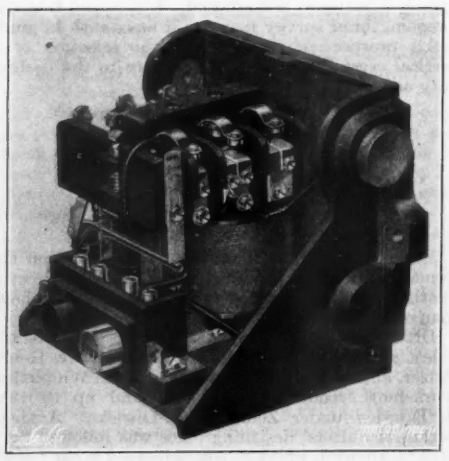
175 B.H.P. OIL SHUNTING LOCOMOTIVE FOR L.M.S. RAILWAY

The tractive effort at starting is 11,200 lb. The oil engine installed in the locomotive is of Harland-B. and W. two-stroke traction type, designed to develop 175 b.h.p. at 1100 r.p.m., and is fitted with an overspeed governor cutting out at 1250 r.p.m. In normal service the revolutions are about 850 r.p.m., but the higher speed mentioned can be used whenever desired for purposes of acceleration. The engine is started by compressed air stored in reservoirs at a pressure of 375 lb. per square inch, charged by a two-stage compressor direct driven from the main engine crank shaft. An auxiliary compressor driven by a 2½ b.h.p. petrol-paraffin engine is also provided. There is also a compressed air service of 100 lb. per square inch for operating the brakes and the whistle, taken from the L.P. stage of the compressor. To facilitate starting from cold a glow plug is fitted in each cylinder, heated electrically from the accumulators. Power is transmitted by means of a Vulcan-Sinclair hydraulic coupling to a two-speed gear-box, and thence by means of a cardan shaft to the front axle of the locomotive. The cardan shaft has the usual universal joints to allow vertical motion of the axle in relation to the frame. The reverse gear is engaged by means of dog clutches whilst the locomotive is at rest. The gears are constantly in mesh. The arrangement of gears for the two speeds and the method of control have received careful consideration for the special purposes of shunting service. All the various motions for changing from low gear to high gear and *vice versâ*, both backwards and forwards, are performed by one lever, which is duplicated on the two sides of the cab. The final drive is obtained through a high-efficiency worm gear.

We are indebted for the foregoing description to Mr. W. A. Stanier, chief mechanical engineer, L.M.S. Railway, and to Harland and Wolff, Ltd.

A New Motor Starter.

THE accompanying illustration shows a new small and compact contactor starter switch recently introduced by the Midland Electric Manufacturing Company, Ltd., of Barford-street, Birmingham. It is suitable for starting A.C. motors up to 2 h.p., and is provided with overload protection on all three phases, and with a no-volt release. All the operator has to do when it is desired to start the motor is to press the "start" button and to press the "stop" button when it is necessary to shut the machine down. As the overall dimensions are only 6¼in. by 4¾in. by 5in., the starter is particularly suitable for mounting on independently driven machine tools. It is supplied for voltages of 200–440, and with current ratings of 1 to 4 ampères, and for starting three-phase or single-phase machines. There is a double break on each phase, and both the fixed and moving contacts are heavily silver-plated.



2 H.P. MOTOR STARTER

ACCORDING to an extract in *Flight*, the Japanese Government has decided that a joint Japan-Manchukuo company shall be established in order to operate services between Tokyo and Singapore and the South Sea Islands, and between Japan and the United States. The company is to purchase three rigid airships, and negotiations have already been opened with the Zeppelin Company.

Practical Bath Manufacture.

(By a Correspondent.)

THE successful moulding of baths depends more upon several practical features than on any fixed rules or directions deduced from theoretical considerations. At the outset, the cupola has to be controlled on thoroughly scientific lines, and any failure in this direction makes it impossible to mould the baths systematically. In ordinary light ironfoundry practice, the cupola is sometimes left in charge of a furnace labourer, and so long as the metal tapped is sufficiently hot to suit the class of castings required, this system suffices. The moulding of baths calls for more scientific handling, and the actual casting will not be a success unless the iron has been properly prepared in the cupola.

The pig iron and scrap are selected to suit a predetermined formula, and the best mixtures usually consist of pig irons taken from different districts. In the final process the bath is enamelled, and is therefore required to possess definite expansion and contraction properties. These cannot usually be obtained from any odd mixture of pig iron and scrap. The charging of the cupola requires to be carried out with precision and accuracy, and in some ways resembles the handling of non-ferrous furnaces, since all materials charged before and after the melting operations are weighed and checked.

One feature of the class of scrap which accumulates in a bath foundry is the large amount of light metal, of thin section, which requires to be used up in the cupola. This has to be broken up into comparatively small pieces, and charged in a fixed proportion.

A more awkward class of scrap to handle is that which comes from the enamelling shop. This is coated with enamel which tends to adhere to the walls of the cupola, and gives rise to small practical difficulties later. Most of the enamel finds its way into the slag, but it is undesirable material. When a charge has been used with much enamelled scrap, small patches will be noted in the lining of the cold cupola, after the work has been completed.

The lining does not last so long when much enamelled scrap has been used, and in some cases such scrap is laid aside and not fully utilised.

Charging the Cupola.

In order to ensure accurate charging, each charge is weighed off individually, but in view of odd lots of light and heavy scrap a certain margin for error must be allowed. The pig irons are weighed off, raised by the lift to the charging floor, and built up in square formation to economise in the space. A rag or piece of paper is placed between the sections, so that no confusion may arise when the cupola men are engaged in filling up the furnace.

Old sacks are placed between the lighter scrap, but in cases where there is much of the latter to handle, approximate accuracy is obtained by simply adhering to a fixed number of shovels per charge. The same system is employed for charging the coke.

When commencing operations in the early morning, the lining is chipped and patched as required, and the kindling first introduced.

The coke is then charged to form the "bed charge." Damp coke will occupy less space than clean, dry coke, but the best results are secured by adhering to a specified volume of coke rather than a fixed weight. Using a cupola of known dimensions, this volume can be checked by lowering an iron disc and measuring from the charging floor. This should be done each morning. The appliance used simply consists of a thin disc of iron cast with a lug, to which is attached a rope on which measurements are marked. If the coke is charged haphazard, the "bed charge" will lie at an angle or slanting position, and this should be avoided. The markings on the rope are measured to the line of the charging door. The first charge consists of light foundry scrap only. These flat pieces, when charged in this way, tend to produce a choking action so far as the blast is concerned, but ensure the metal being hotter at the commencement. It has been found that when a mixture of scrap and pig iron is used for the first charge, the temperature never attains its full value. The choking action which the flat pieces effect on the blast, increases the pressure locally, and invariably gives metal which may be tapped at the desired temperature.

In some cases, in the writer's experience, it was found that old, damp coke burned better than fresh, dry coke. A rough indication of the condition of the coke was obtained by testing samples in water; fresh coke floated as usual, but the older material, being heavier, sank.

The charging of the different lots of pig iron and scrap was then carried out in the usual manner, care being taken that each charge was level. This was checked by using the iron disc referred to above. The coke was introduced in a fixed number of shovels, taken from each individual bogie from the weighing machine, and the possibility of error was thus minimised.

There are, no doubt, all kinds of methods of kindling the cupola, and where the tapping temperature of the iron is of no special account, the first lot is generally employed for some rough heavy casting. Such castings are somewhat rare in a bath foundry, and, further, it does not always follow that the succeeding charges will be tapped at a greatly increased temperature. Hence, the kindling has to be made so that when the blast impinges on it, the flames will spread evenly around the coke of the bed charge. It is customary to allow a fixed time to elapse between the period of kindling and the turning on of the blast. Too lengthy a period causes part of the coke of the bed charge to burn away, and leave cold ashes at the bottom of the furnace. In conducting practical research work on this point, assistance can be gained from the methods adopted by smelters of non-ferrous metals in small blast-furnaces, where the same kind of troubles with cold bottoms occur.

Slags should be periodically analysed, and the lime addition varied to maintain it at the desired composition. The amount of iron retained in the slag should be determined by crushing samples, and separating the metal. All scrap accumulating from old risers, runners, gates, &c., from each day's work must be weighed, and checked with the amount of iron charged into the cupola. Each lot of metal as it is tapped from the cupola is examined through melters' blue glasses, and a considerable amount of information can be gathered in this way, apart from a good indication of the temperature. There does not appear to be any definite method of arriving at the carbon content of the iron, but the appearance of the molten metal gives a comparatively accurate result for the silicon and manganese content. A considerable number of tappings are made, and the approximate analysis from the appearance is noted individually. The average of these is then taken and recorded as the analysis of the metal. This is checked frequently by ordinary chemical analysis. With continual experience, the figures so obtained are wonderfully accurate.

The iron is tapped into bogies which are run into the moulding shop, and thence to the bath moulds. A note is made of the slag as regards its temperature and approximate viscosity. A good rough test of the latter simply consists in noting the time which a pot of slag takes to flow down an iron plate fixed at a specific angle. Slag tests so made may be accepted as a good indication of the nature of the melting.

Casting the Baths.

Instead of using the ordinary wooden patterns for obtaining the impressions in the sand, concrete blocks are employed.

These are made of selected preparations and represent the sides and bottom of the bath with great precision. An ordinary concrete block suffices for the purpose of taking the outside impression of the bath, but the block which has to act in the capacity of the core or inner side has to be specially made as it has to withstand the effects of the molten iron, and not go out of shape for succeeding castings. An iron box, not unlike a bath in shape, but open on top and bottom, is lowered over the ordinary concrete block and sand rammed in by hand. The top of this box represents the bottom of the bath. Pins are fitted to the bottom of the concrete block so that when the iron box is lowered on to it, the latter lies exactly in position, and requires no further adjusting. One ordinary concrete block suffices for the taking of impressions of the outer walls of the bath, but a "special" concrete block is required for the inner walls of each individual bath. That is, where eight baths are to be cast, eight "special" blocks are required. They are arranged in a circle on the foundry floor, with a small jib crane in the centre. The ordinary concrete block is placed outside this circle. The iron box is transferred by bogies to the latter, and the sand rammed into it, as already noted.

The iron box with the sand impression of the outer dimensions of the bath is then raised by the crane and lowered on to a "special" concrete block, which has previously been coated with plumbago or black moulding sand. Pins are fitted to the latter block as to the former block, so that the iron box is lowered into position with accuracy. Now it should be understood that certain builders' associations specify that the baths are not to exceed a certain weight, and this is generally adhered to. It is a much simpler job for the moulder to make a bath of thicker section, but this liberty is not permitted. Although the pins cause the moulds to lie in exact position, the depth to which the iron box is lowered is varied at the discretion of the moulder.

The cupola iron is cast into the top of the mould. The art of successfully casting baths almost entirely rests on this process. There are numerous small practical points whereby the cupola iron may be made to fill up the mould evenly, the latter being suitably "vented." The operation of pouring the iron consists in running a bogie of the metal from the cupola to the side of the moulding boxes. The metal is poured into pots which are raised by hand and emptied into a built-up sand section which lies above the moulding box. The iron fills this up and descends into the mould in an even stream. If the mould has not been properly "vented," the even evacuation of the iron from the sand section to the mould will not take place.

The work is carried out systematically in conjunction with the working of the cupola, and the different sets of baths are cast in a pre-arranged manner, so that no possibility arises of metal being cast which is not sufficiently hot. As a result of long experience, the moulders are aware when the metal is not in the desired condition, and reject it. In these cases the moulding boxes are left standing until the next day, when more care is devoted to the working of the cupola.

No moulds are made up prior to even short vacation periods, as in this way the sand would be unduly dried, and not furnish soundly cast baths. In some firms bonuses are paid to the moulders who successfully cast the most baths per day.

Some moulders prefer to disconnect the moulding boxes whilst the cast bath is still in a dull red-hot condition. The sand is emptied out, and used over again for the next day's moulding, in the usual way. These baths are left standing in position on top of the inner block until the next day. The cold baths are then inspected and weighed, and any wasters rejected. They are then dressed with the assistance of a grinding wheel, and finally sand-blasted. This completes the work so far as the foundry is concerned.

By adopting the latest methods of welding practice, it has been found that many of the earlier rejected baths containing slight cracks and blemishes could be repaired. This introduced a considerable economy, and well repaid the cost of the special welding system. Prior to adopting welding, pins were inserted in small fissures, &c., and specially hammered into shape, but these did not give the same satisfaction as the welding process.

The completed baths are transferred to the enamelling shop, where they are first annealed prior to applying the enamel. A fully detailed record is kept of the breakages sustained throughout the different stages of the manufacture, and these are compared in conjunction with the different iron and enamel compositions employed. Certain iron compositions which moulded well and give little or no trouble in the foundry are found to break more readily during annealing and enamelling.

British Standards Institution.

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria-street, London, S.W.1. The price of each specification is 2s. 2d. post free, unless otherwise stated.

WELL GLASS LIGHTING FITTINGS.

No. 238—1934. This is a revision of the specification for underground lighting fittings for use in mines. It provides for 60-watt non-flameproof well glass for use underground in coal mines in the areas prescribed by the Coal Mines General Regulations (Lighting), 1934. In this revision the specification has been modified to provide for underground lighting fittings suitable for use with gas-filled lamps. Larger clearances have been stipulated and the specification now requires that packing rings shall be made of asbestos or some material other than rubber capable of withstanding indefinitely in service a temperature of 212 deg. Fah. without deterioration.

GLASSWARE LIGHTING FITTINGS.

No. 324—1934, No. 364—1934. When the Illumination Section of the British Standards Institution was formed one of its first efforts in standardisation was in the very difficult field of translucent glassware, and in 1928 the first specification was published. Since that date considerable progress has been made, particularly in Great Britain, in the theoretical side of diffusion in glasses in its relation to the size and concentration of the particles causing the diffusion and as a consequence great practical improvements have been made in manufacture. Whereas formerly it was considered axiomatic that good diffusion was inevitably accomplished at the expense of light transmission, it is now possible to have opal globes with transmissions approaching 90 per cent.

In the revised, as well as in the original, specification the diffusing power of the glassware is looked after by a clause which states that the geometric form of the filament of a clear electric lamp or of a gas mantle shall not be visible through the glassware and that the brightness of the glassware shall not exceed 5 candles per square inch in any direction in which it is viewed in actual use.

The relative dimensions of glassware, lamps, and the galleries have received attention and have been standardised. The heat-resistant clauses have been modified in the revised specification as the result of research work both on fittings used with gas mantles and on those used with electric lamps. The most important alteration in the revised specification is, however, its insistence on a high transmission value for glassware. A table is given of the minimum transmissions for totally enclosed glassware for different angular diameters of the neck diameter. The method of testing this requirement is specified in more detail than in the original specification.

The neck and flange dimensions of the glassware and carriers are given in a separate specification B.S.S. No. 364—1934 (revised), together with the diameter of the clearance hole in shades, reflectors, or their appropriate galleries for the B.S. bayonet lampholder.

ASBESTOS CEMENT PIPES.

No. 569—1934. This new specification deals with the dimensions and workmanship of asbestos-cement rain water pipes and gutters. It includes a comprehensive range of standard forms of pipe and gutter fittings for use in connection with rain water systems. The standard form of socket secures interchangeability and enables replacements to be made with the minimum amount of adjustment.

SCIENTIFIC GLASSWARE.

No. 571, No. 572—1934. These Specifications cover Distillation Flasks and Interchangeable Conical Ground Glass Joints respectively. They are the first glassware specifications to be issued by the Scientific Glassware Committee, which was taken over from the Institute of Chemistry when the Chemical Division of the Institution was formed. The Distillation Flask Specification (No. 571) provides for a complete series of fourteen flasks ranging from a distillation capacity of 30 ml. to 3000 ml. Prior to the publication of the specification over this range of capacity four manufacturers were making between them flasks having twenty different nominal capacities, and having forty different bulb capacities. The general adoption of the standard series will therefore not only diminish the different sizes of flasks now being made, but will also ensure identity of actual capacity between flasks having the same nominal capacity.

The following three conditions are fulfilled by each flask in the series:—

1. The centre of the side tube is 75 mm. from the top of the neck.
2. The centre of the side tube is 90 mm. from the liquid surface when the flask is vertical and contains a quantity of liquid equal in volume to the distillation capacity of the flask.
3. The bulb capacity is 30 per cent. greater than the distillation capacity.

The first condition ensures the same immersion of the stem of the thermometer in each size of flask, the thermometer being placed so that the top of the bulb is level with the bottom of the side tube at its junction with the neck. Thermometers calibrated for 100 mm. immersion are convenient for use with the flasks. When the thermometer is fixed as directed above, the immersion line of the thermo-

meter will be in the neighbourhood of the top of the cork holding the thermometer in position in the neck.

The second condition helps to secure reproducibility of results in distillation by ensuring that the thermometer bulb is at a constant distance from the level of the liquid surface at the beginning of a distillation.

The third condition ensures a definite bulb capacity for each nominal capacity, the bulb capacity being taken as 30 per cent. greater than the distillation capacity. Considerable variation was found in the bulb capacity of flasks from different sources having the same nominal capacity.

The Specification for Ground Glass Joints (No. 572) has been prepared to secure the interchangeability of conical ground glass joints in laboratory and industrial glassware.

In order to ensure interchangeability the following elements have been specified for each joint :—

1. Taper.
2. Diameter of larger end of socket.
3. Diameter of smaller end of cone.
4. Length of ground portions of cone and socket.

A taper of 1 in 10 on diameter, equivalent to a cone semi-angle 2° 51′ 45″ has been adopted for all joints.

To meet the requirements of different types of apparatus four series of standard joints designated Series A, Series B, Series C, and Series D have been provided.

The dimensions for the standard Series A have been chosen to fit in with foreign standards already in existence. Joints in the additional series have the same diameter at the larger end as the corresponding joints in Series A, but have different lengths of engagement thus :—Series B, three-quarters ; Series C, a half ; and Series D, a quarter the length of Series A.

The four series of joints together afford a very wide choice, so that provision is made for the replacement of existing joints and for special requirements. It is considered, however, that the following sizes would meet almost all normal requirements :—

A. 14, A. 16, A. 19, A. 24, A. 29.
B. 24, B. 29, B. 34, B. 40, B. 45, B. 50.

It is therefore recommended that these sizes be adopted for general use, and that the remaining sizes be only employed when it is impossible to use one of the recommended sizes.

The dimensions and tolerances specified were only adopted after very careful measurement and examination of conical ground glass joints in present-day use. This work was carried out at the National Physical Laboratory, and the Committee entrusted with the preparation of this specification desires to record its indebtedness to the Laboratory for these investigations.

The Committee is also indebted to the National Physical Laboratory for assistance in the preparation of the appendix giving suggested methods for gauging the joints. These methods are given for the guidance of manufacturers, but it is, of course, open to a manufacturer to use any method of gauging which ensures that his joints comply with the dimensions and tolerances given in the specification.

It is also important to note that in regard to both of these specifications the National Physical Laboratory is prepared to accept apparatus for test for conformity with the foregoing specification.

SOLVENTS.

Nos. 573 to 580—1934. These eight specifications deal with diethyl phthalate, dibutyl phthalate, technical ether, carbon tetrachloride, hexachlorethane (hexachloroethane) trichlorethylene (trichloroethylene) (technical and stabilised), and technical glacial and acetic acids. Limits fixed by agreement between the principal users and manufacturers are laid down for specific gravity, distillation, acidity, alkalinity, &c., whilst standard methods of test for determining these properties are included in appendices.

American Engineering News.

Modern Trestle Bridges.

WITH large supplies of timber, and a great increase in the use of wood preserving processes, the timber trestle bridge is in many cases advantageous and economical on American railways, particularly on lines of relatively light traffic. Timber truss bridges are now rare on railways, although they are used to some extent on highways in States having abundance of suitable timber. Under present practice much of the cutting, framing, and boring of the timber is done before treatment, thus avoiding the unsatisfactory method of cutting away treated wood. Trestles are of two general types : pile and frame. In the former the piles form the foundation and the structure, extending above ground high enough to support the deck. In the latter the piles are for foundation only and support a superstructure of square timbers and plank. The length of span is usually 12ft. to 15ft., formed by groups of longitudinal timbers resting on the caps or transverse timbers on the pile heads. In many cases the sleepers or ties rest directly on the longitudinals, but modern practice is rather to place a plank deck and carry the ordinary ballasted track over it. In a new double-track pile trestle of the Illinois Central Railroad, with a height of about 20ft. and a length of about two miles over swampy ground, there are twelve piles in each group or "bent," the two outer piles on each side are battered, and all are covered with the "cap," a 14in. by 14in. timber. Plank bracing is applied on each side of each "bent." Upon the caps is a plant deck with ballasted tracks. To prevent spread of fire thin concrete walls or piers are built at intervals, extending to the tops of the sleepers. Steel spans on concrete piers are also introduced at intervals, for the same purpose, owing to the great length of the bridge. A novel feature in another long trestle is the use of 20ft. spans of steel joists, instead of the usual timber longitudinals. In earlier days framed trestles were built of great height, but steel or concrete bridges are now generally used in such cases, and trestle construction is limited mainly to low structures. Concrete trestles represent a modern development from the older timber construction.

Portland Cement Developments.

A new specification for Portland cement, proposed by the American Society for Testing Materials, points to two important changes. First, the use of different specifications for cement for different purposes, in place of the present uniform standard specifications ; and second, the elimination of the classic tensile test of sample briquettes in favour of a crushing test of cubes. In recent years the introduction of high-early-strength cements has led to departures from the standard specifications, but the proposed change goes farther in making a different chemical requirement. Classed as sulphate-resistant cement, and designed to result in concrete of greater durability by its resistance to sulphate solutions, it is high in iron content and low in tricalcium aluminate. Another specification for a low-heat cement is also in preparation, since there is a large demand for such a cement in the construction of several of the large dams proposed or being built by the U.S. Government. Under a newly developed system of cement manufacture, cement of high quality may be made from relatively inferior raw material or cement rock, the process consisting of the application of the flotation principle for separating the lime-bearing ingredients from the silica, alumina, and iron. Thus an excess of free silica can be removed and the constituents of the rock proportioned as desired. The first new cement plant built for some years is that of the National Portland Cement Company, which is to be put in operation before the end of 1934, with an annual capacity of 1,250,000 barrels. From the wet grinding mills the slurry will be pumped to kilns 10ft. in diameter and 400ft. long. From the clinker bins the clinker will go to the grinding mills, the finished product of which is conveyed by a blower system to the cylindrical storage bins, 25ft. in diameter. The group of twenty-five bins has a capacity of 250,000 barrels. Another blower system delivers the cement to the packing house, which is equipped with pneumatic packing apparatus. Electric power is used throughout the plant.

American Aviation Developments.

New regulations adopted by the United States Department of Commerce define "airways" as strips 50 miles wide, with their centre lines connecting terminal points. Pilots must fly within the defined limits, except in case of emergency, and must then explain their reasons in writing. Air routes are subdivided into divisions, each being that portion which is flown regularly by a pilot as a round trip, and pilots will be licensed only for one division. Control of operations within each division will be in the hands of a licensed dispatcher. Rates for lightweight air express have been reduced, and special excursion rates have developed extensive tourist traffic. An air trip from Florida to Brazil and across to the Pacific can be made in six weeks. All concerns carrying air mail are now required to report to the Interstate Commerce Commission, showing the cost of operating the planes and of flying the mail. A lighted airway is to be established from Washington to Nashville, 600 miles, for which funds have been provided by the U.S. Government. Two aircraft carriers for the United States Navy are being built, similar to the "Ranger," now in service. Each will have 20,000 tons displacement, carry seventy-two aeroplanes, and cost about £3,600,000. About 2000 planes are to be built for the Navy, and extensions made to the naval aircraft factory and training school. Airport construction is one of the items in the Government programme for relief works. About £14,000 will be provided, or nearly one-fourth of the estimated cost of the airports selected. An island airport for Chicago seems unlikely to be built, since it would be unsafe in stormy weather and fogs, while the city has for years been clearing its water front from industrial plants in order to develop it for public parks. At New York, however, an airport on Governor's Island, in the harbour, is being considered by a board of army officers. Of 414 forced landings on account of mechanical defects in twelve months, 280 were due to engine failures, 35 to *personnel*, 34 to radio, 19 to instruments, and 18 to aeroplane defects.

Composite Ingots for Composite Steels.

Composite steels, such as high-alloy chrome or chrome-tungsten steel, permanently bonded to ordinary steel, are being produced commercially in the United States under new processes developed in the research department of the Jessop Steel Company. They include veneer metal in which a body of low-carbon steel is surfaced on one or both sides with nickel or stainless steel, or with Monel metal ; also, tough low-carbon or lightly alloyed steel having a working edge of tool steel. In all cases such composite steel is made from a composite ingot, in which the cheaper metal is cast around inserts of the higher quality steel. The latter is thus completely enveloped within the former and is not exposed at the surface until the two have been united in a permanent bond by hot rolling. This type of process has been found simpler, cheaper, and more satisfactory than earlier attempts at welding the two components by surface fusion, or otherwise bonding them when in a semi-finished state. The production of veneer steels is based upon the formation of at least one weldable and one unweldable plane within the ingot. These planes are parallel and extend nearly the full width and from top to bottom of the ingot, but are not exposed at its surfaces. When the ingot is rolled, the laminations adjoining the weldable plane are permanently bonded together, while those adjoining the other plane are not bonded. The planes are formed by an insert consisting either of a single plate of the veneer metal having one side coated with a weld-preventing material, or two or more such plates may be used, with their coated sides in contact, the plates being so securely fastened together as to prevent the molten steel from penetrating between them. Ordinarily, only one such insert is placed in the mould, but at least two are necessary for plates and sheets that are veneered on both sides. The ingot is rolled to approximately double the thickness required for the finished product ; the marginal edges of soft steel are trimmed off and the two parts are then separated along the non-weldable plane.

A 250-ton Navy Crane.

For refitting work and the handling of large turret guns at the Puget Sound yard of the United States Navy Department, there has been installed a cantilever or hammer-head revolving crane with a hoisting capacity of 250 gross tons. Its steel frame tower is 40ft. in diameter and 125ft. high, with a circular track at the top for the revolving boom, which consists of a pair of horizontal trusses 317ft. long. The cantilever arm is 196ft. 6in. long from the centre of rotation, while the counterbalancing arm is 120ft. 6in. Along this boom travel two hoisting trolleys of 125 tons capacity, having a working radius of 125ft. In addition, there is one trolley of 30 tons and two high-speed trolleys of 5 tons capacity, each with a travel or working radius of 184ft. The maximum lift of the main hoists, working separately or handling a 250-ton load, is about 115ft. A two-storey machinery house on the counterbalancing arm has a 25-ton travelling crane for handling the machinery, and at the extreme end of the arm this crane handles its loads to and from the ground. For the main hoist, with 250-ton load, the speed is 7½ft. per minute, while for the 30-ton hoist it is 15ft. The trolley travel is 40ft. per minute for the main hoist, and 100ft. for the auxiliary hoist, while the swinging or revolving speed is six minutes for a complete revolution. All operations are effected by electric power, with magnetic control, two 100 h.p. motors serving the main hoist, and one 50 h.p. motor the 30-ton hoist. By placing the operating cabin under the revolving member, and just clear of the supporting tower, the operator has been given a clear view of all the hoisting hooks in any position. For swinging, there are two vertical-shaft pinions engaging a circular rack on the top of the tower. When handling a load of 125 to 250 tons, the two main hoists are connected by electric clutches ; a similar arrangement is made for traversing the hoist trolleys with such loads. Each 125-ton hook is carried by a twelve-part tackle of 1¼in. wire rope. The aggregate power of all motors on the crane is 450 h.p.

LAUNCHES AND TRIAL TRIPS.

ACAVUS, single-screw motor oil tanker ; built by Workman, Clark (1928), Ltd., to the order of Anglo-Saxon Petroleum Company, Ltd.; dimensions, 460ft. by 59ft. by 34ft.; to carry oil in bulk. Engines, Werkspoor-Diesel type ; launch, November 24th.

CONTRACTS AND ORDERS.

The Editor is always happy to print short announcements of contracts and orders in this column provided they are sent to him in time to have news value and that they are likely to interest readers.

THE FRETWELL HEATING COMPANY, Ltd., 301, Abbey House, Victoria-street, London, S.W.1, has recently secured an order for equipping the new Odeon Cinema, Guildford, with heating and air-conditioning equipment.

THE MITCHELL COMPANY has secured an order for four Tri-drum bent-tube type M-W boilers for the Portishead power station, Bristol. These units, which are to be stoker-fired, are designed for a steam pressure of 325 lb. per square inch, and a steam temperature of 800 deg. Fah., at the superheater outlet.

THE RUTHS INTERNATIONAL ACCUMULATOR COMPANY has secured an order for the City of Amsterdam, where the municipality is now installing a large plant at the Nord electric power station. The plant is to cover the peak load and will act as a momentary standby, providing 15,000 kW of power for forty-five minutes.

THE NECKAR WATER SOFTENER COMPANY, Ltd., 96, Victoria-street, Westminster, S.W.1, has received an order for water softening plant having a capacity of 6500 gallons per hour from the Mossfield Colliery Company, Ltd., Stoke-on-Trent ; and an order for two plants for boiler feed purposes from Gibbons (Dudley), Ltd.

THE ENGLISH ELECTRIC COMPANY has received an order for two 3-K type Diesel engines, each developing 150 b.h.p. at 600 r.p.m., direct-coupled to 100 kW alternators with all motors and control equipment for the gravel plant, motor-driven pumping sets, &c., at Kut Barrage. It has also received an order for three 6-K type Diesel engines, each developing 300 b.h.p. at 600 r.p.m., direct-coupled to 200 kW generators, with motor generator sets, motor-driven pumps, complete transmission line across the dam, and all power-house equipment for the Assiut Dam reconstruction works.

"INDIAN CONCRETE JOURNAL."—The October issue of the *Indian Concrete Journal* is practically wholly devoted to the disastrous Indian earthquake of January last, and is principally composed of illustrations showing the destruction wrought upon buildings. Naturally, some accent is laid upon the superior resistance to shock shown by concrete structures and buildings in which cement mortar is used instead of lime mortar. There are a few articles, and the lessons of the earthquake are summarised in a page of large type. The first two recommendations are to avoid arches and to make buildings as monolithic as possible. The publication is admirably printed and will be valuable to architects and engineers not only as a record, but as an indication of what to avoid.

ENGINEERS' GERMAN CIRCLE.—The last meeting of the Engineers' German Circle for the 1934 session was held on Monday evening, December 3rd, at the Institution of Mechanical Engineers, under the chairmanship of Dr. S. J. Davies. The lecture was given by Mr. K. H. Panzerbieter, of Siemens-Schuckert (Great Britain), Ltd., who spoke on automatic welding machines. The lecturer dealt with different profiles for welding, and showed examples of the work accomplished by automatic welding machines using coiled wire electrodes, and also carbon-arc welding with paper-feeding attachments. Various types of machine designed for long longitudinal welds, circumferential seams, and curved automobile chassis members were described, and details of their design and performance given. The lecture closed with an excellent film showing the machines in actual operation. The thanks of the Circle to the lecturer were warmly expressed by Dip.-Ing. Bondy, and a very good discussion followed. After the meeting an informal dinner took place at the D'Abernon Club, 6, Carlton-terrace.

Markets, Notes and News.

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer. A comprehensive list of the prices of materials mentioned below will be found on the next page.

The American Steel Position.

A bulletin issued by the American Iron and Steel Institute presents a rather gloomy picture of American industry. It estimates a deficit on the earnings of the American steel trade for the first nine months of the year at 8,300,000 dollars. During the second quarter of the year the steel works were busy, the average rate being 53·9 per cent. of capacity, and the aggregate profits for this period totalled 24,600,000 dollars. The position began to deteriorate early in July, and the average for the third quarter fell to 24·1 per cent. of capacity and resulted in a deficit for the three months of 25,000,000 dollars. The bulletin points out that in spite of low production for the third quarter, the average hourly earnings of steel companies' employees reached 72·7 c., an increase of 3 per cent. over the second quarter. Although there was a profit for the second quarter of 2·65 dollars per ton of steel ingots produced, in the third quarter this was transformed into a loss of 6·10 dollars. This estimate for the third quarter is based upon returns from seventeen companies, representing 85 per cent. of the producing capacity of the industry. Reports from companies operating more than 99 per cent. of the steel capacity of the United States for the first half of the year show that the returns on investment during that period were only 0·86 per cent. Owing to the poor rate of operations in the third quarter of the year, the combined deficit was greater than the combined profit in the first half. The taxes paid by the industry, it is stated, have doubled within the past three years, 80,000,000 dollars per annum having been paid since 1931. This is equivalent to 6·1 per cent. of the sales. The statement adds that "in view of the financial losses for the industry during the current year, there would appear to be no foundation for the recently circulated rumours that drastic reductions in steel prices are imminent. The sharp decline in operations in the industry has come from the tremendous slump in demand from the so-called durable goods industries, building construction, railroad equipment, and similar heavy industries."

Pig Iron.

The pig iron market has been rather less active this week, but a period of quieter trading was only to be expected after the busy fortnight which the trade had experienced. A number of contracts were entered into during the latter part of November, many of them renewals of old contracts, which were extended to provide for deliveries in some cases up till April of next year. This week, however, business has been almost entirely confined to small parcels, but in the aggregate these have reached a substantial tonnage and indicate that the consumption of foundry and hematite iron is not really decreasing. In some instances consumers have not renewed contracts probably because they believe that prices are not likely to change during the next few months and that they will be able to obtain their supplies as they require them. On the North-East Coast the position is particularly good from the producer's point of view. There are four furnaces producing Cleveland, ten are making hematite, whilst thirteen are employed on "other kinds." The production of the four furnaces is entirely taken up and lately there have been withdrawals from the moderate stocks in the producers' hands. Until the New Year it is probable that the make will be sufficient to meet the requirements of the market; but later on there are anticipations that it will be necessary for more furnaces to be put into commission on foundry iron. The Cleveland makers are still experiencing a strong demand from the light castings industries on the North-East Coast and in Scotland. The Midland pig iron producers, however, report that business with the light castings foundries in their district has fallen off somewhat, and attribute this to seasonal influences. There was a distinct lull in the demand during the early part of November and the consequent holding up of deliveries to consumers has not yet been made good, so that in all probability the year will end with a certain number of contracts uncompleted and presumably the balances will be carried forward. A bright feature of the market is the demand from the heavy engineering industries.

North-East Coast and Yorkshire.

The position on this coast is more satisfactory than at any time since the early summer and greater confidence is noticeable in all departments of the market. The shipyards in this district did not share in the improvement in that industry to the same extent as those on the Clyde; but lately more orders have come their way. The expectation that a shipping subsidy will result in the scrapping of old ships and the building of new has created a cheerful tone, whilst some of the mills which for a long time were short of work have already benefited from the orders recently placed. The works producing railway material are moderately busy and expect to receive some substantial orders in the New Year. The position regarding export business, however, is obscure owing to the uncertainty regarding the future of the International Railmakers' Association. Negotiations for the prolongation of the agreement have been going on for some time, but the situation has been complicated by discussions which have been taking place between the British and Continental works on wider questions of trade policy. The demand for billets and sheet bars has been steady rather than active; but on the whole the works producing these descriptions have a good tonnage of orders on their books and current business is of fair dimensions. Most of the constructional engineering firms are busy and the orders reaching the steel works from this industry amount to a good proportion of the total. It is interesting to note that in spite of one or two periods of slack trade this year the steel production of the district amounted to 1,361,300 tons for the nine months ending September 30th, compared with 1,315,900 tons for the corresponding period of 1933. There has been little change in the situation in the Yorkshire steel industry during the past few weeks. The production of basic steel is at a high level and some of the producing works are operating at capacity, whilst the output of acid steel has been well maintained. Business in stainless steel has declined somewhat, but the demand for special steels, particularly from the aeronautical works, has strengthened. Lately there has been an active call for acid billets. The associated high speed steel twist drill manufacturers have decided that as from December 3rd the maximum discounts for high speed steel twist drills will be as follows:—All standard high speed steel jobbers, 67½ per cent. and 2½ per cent. off the list; All standard 18 per cent. tungsten high speed steel taper shanks, taper length and ratchets, 65 per cent. and 2½ per cent. and 2½ per cent.; All standard 14 per cent. tungsten high speed steel taper shanks, taper length and ratchets, 67½ per cent. and 2½ per cent.

Scotland and the North.

The steel trade in Scotland has been cheered by the run of new orders which has been placed with Clyde shipbuilders lately. Apart from a cruiser, which it is expected will cost about two million pounds, contracts for an 8000-ton cargo steamer, and tugs, dredgers, lighters, and a coaster have been placed. All this means work for the steel makers in the near future in the production of plates and other shipbuilding material. Although a good tonnage of steel is being delivered to the shipyards, the works have completed a number of large contracts and are rapidly approaching the end of others, so that these new orders will be welcomed. The structural engineers are well employed and the demand from this industry for joists and sections keeps at a good level. The machinery makers, also, are taking fair supplies of steel, but, on the other hand, activity in the tube trade has slowed down and one of the works has gone back to a two-shift from a three-shift working. The Scottish sheet industry has participated in the improvement in the demand. The export trade is not strong, but it has provided a few substantial orders lately, which have helped the position at some of the mills. The home trade continues to absorb the greater part of the output, but recently Indian business has expanded. In the Lancashire market business has been steady and good quantities of sectional material have been taken up by the constructional engineers. It is anticipated that the requirements of this branch will increase during the next month or two, although the season is approaching when a lull in trading usually takes place. A moderate volume of business has been transacted in re-rolled material lately and most of the Lancashire re-rolling works have good order books. Competition, however, is keen in this district between the associated and the unassociated makers.

Current Business.

A contract for an oil tanker for Arneson, Christensen and Smith, of Newcastle, has been secured by Swan Hunter and Wigham Richardson, Ltd. A twin-screw passenger liner of 11,000 tons gross register has been ordered by the British Indian Steam Navigation Company, Ltd., from Barclay Curle and Co., Ltd., of Whiteinch. Hawthorn Leslie and Co., Ltd., of Hebburn-on-Tyne, have booked a contract for a cargo steamer of 9500 tons for J. and C. Harrison, of London. The English Electric Company, Ltd., has secured an order for two Diesel engines developing 150 b.h.p. at 600 r.p.m. for the Kut Barrage, Iraq, and three Diesel engines for the Assuit Dam reconstruction. A contract to build thirty Collin regenerative coke ovens for the Lambton, Hetton and Joicey Collieries, Ltd., has been obtained by Gas Chambers and Coke Ovens, Ltd., of London. The Harland Engineering Company, Ltd., of Alloa, has obtained a contract from the City of Riga for the supply and erection of all the machinery required by the new city waterworks. The Department of Overseas Trade announces that the following contracts are open for tender:—South African Railways and Harbours: Supply of material, preferably protected metal or asbestos, for complete covering of the main and engine-room roofs of the precooling store at East London, including all fastenings and erection (Johannesburg, December 24th); Australia, Posts and Telegraphs Department: Telephone timing clocks (Melbourne, January 29th); Brazil, Viacao Ferrea do Rio Grande do Sul: 14,000 kilos. of round head rivets, various sizes (Brazil, December 28th); a Polish firm requires quotations from United Kingdom manufacturers of hard bright brass strip, 105 mm. wide, 0·12 mm. thick, in longest possible lengths, for casing iron tubes; New Zealand, Christchurch Drainage Board: Supply and delivery of three electrical sewage pumping sets, with horizontal pump direct-coupled to electric motor, starters, pipes, valves, &c. (Christchurch, April 5th).

Copper and Tin.

Whilst business in the electrolytic copper market is still below the normal for this time of the year, a rather firmer tone has developed and buying has been appreciably better than for some weeks past. No definite news regarding the negotiations which have been in progress between the world's copper producers has been received, but buyers are inclined to take an optimistic view and to anticipate that a scheme for restriction of output will be decided upon before the end of the year. Some of the recent buying movement was due to consumers taking the view that they could not go far wrong by laying in stocks of electrolytic copper at the current price. The volume of business, however, has not been anything like sufficient to indicate a general movement in this direction. The market seems convinced that there are no accumulations at consuming works and no hidden stocks, and that restriction of production if and when it comes will be reflected in substantial buying. It is also pointed out that the recent reports of some of the copper companies show that even those concerns which can produce cheaply are experiencing financial stringency as a result of the low price of the metal. In the standard market there has been a considerable amount of speculative buying, but this was met by free offerings of copper, it was presumed, by the American producers. Although there is a fair-sized bull account now open, most of the copper was bought at low prices. . . . The outstanding event of the week has been the publication of the November tin statistics, which are more favourable even than had been expected. According to W. H. Gartsen's figures, the visible supply fell 1782 tons to 14,453 tons, whilst the deliveries during November reached 8507 tons, compared with 5801 tons in October. A feature of the statistics was that the American deliveries increased from 2925 tons to 4845 tons in November. The carry-over in the Straits Settlements and at the Arnheim smelter showed practically no change from the previous month, the figures being 4145 tons in November and 4149 tons in October. It might have been expected that such favourable figures would have resulted in an advance in price, but with the market so firmly under control, there was little alteration in values.

Lead and Spelter.

Whilst the demand for pig lead from consumers in this country is maintained at a high level, Continental requirements fail to expand. These conditions have ruled for several weeks and it is scarcely surprising that speculative interest is almost dead. The heavy purchases by Russia, which were a feature of the market a short time ago, have not been repeated and buying has been of a hand-to-mouth character. The seasonal activity of the battery makers, which springs largely from the demand from the motor car manufacturers, is one of the features of the trade in this country. Good deliveries also continue to be made to the pipe and sheet manufacturers. In the United States the demand fails to improve and the low quotation of 3·50 c. New York rules. Apart from its sentimental influence upon business, however, the position in America does not affect conditions in the London market. . . . The tone of the spelter market has developed an irregular tendency during the past week or two. For some time values in this department have been on the easy side, but over the end of the month the prompt position, as usual, became somewhat tighter. The situation on the Continent is by no means clear, and although it is reported that the new smelter at Magdeburg is not in full operation, a certain amount of metal which normally would have gone to Germany must now find another market. The position with regard to the International Zinc Cartel is obscure; but it seems to be taken for granted that it will be dissolved at the end of the year. It is difficult to foresee the effect this will have upon the market, as although there may be unrestricted competition some high-cost producers may find it difficult to keep in operation.

Non-ferrous Metal Average Quotations.

The official non-ferrous metal average quotations issued by the London Metal Exchange show a slightly better tendency than for several months. The quotations for tin and lead are down slightly, but the average for copper, which has declined over a series of months, has improved to the extent of several shillings. The quotation for cash copper is higher by 9s. 8d., whilst for three months the gain over the October average is 10s. 4d. The average for electrolytic copper is 12s. 10d. up, and that for wire bars shows an increase of 10s. 11d., whilst the best selected copper quotation advanced 7s. 9d. compared with the October price. The market for tin has been practically pegged at around £228, but, of course, there have been fluctuations, and the official average quotation for November is £2 0s. 3d. lower than for October; but on three months tin the quotation is only 9d. less. Lead prices have been so steady for the greater part of this year that little change in the average could be expected. On shipment for the current month the quotation gained 1s. 5d. over the October figure, whilst for shipment for the third following month the November average advanced by 10d., the mean being 1s. 2d. up. The weaker tendency of the spelter market during the latter part of November was responsible for a reduction in the average for shipment in the current month by 4s. 4d., compared with the average for the previous month, whilst for shipment the third following month the quotation dropped 1s. 5d. The mean was 2s. 11d. down compared with the October quotation. The following are the official average quotations for November:—

		£	s.	d.
STANDARD COPPER	Cash	£27	5	5 23/24
	3 Months	£27	12	0 3/4
	Settlement	£27	5	5 1/4
ELECTROLYTIC COPPER		£30	10	4 1/2
ELECTROLYTIC WIRE BARS		£30	16	4 1/4
BEST SELECTED COPPER		£30	3	7 1/2
STANDARD TIN	Cash	£228	13	4 19/20
	3 Months	£228	16	0 1/4
	Settlement	£228	13	10 1/4
LEAD	For shipment the current month	£10	8	7 1/4
	For shipment the third following month	£10	11	11 3/4
	Mean	£10	10	3 3/4
	Settlement	£10	9	3 1/4
SPELTER	For shipment the current month	£12	0	0 1/2
	For shipment the third following month	£12	5	7 1/2
	Mean	£12	2	9 3/4
	Settlement	£12	0	2 3/4

Current Prices for Metals and Fuels.

Makers' official home trade prices, per ton, delivered buyers' stations. Sections, joists and plates are subject to a rebate to home users purchasing only from associated British Steelmakers: joists, 22s. 6d.: plates and sections, 15s. Export orders of 250 tons and over may be subject to special quotations.

PIG IRON.

	Home.	Export.
	(*D/d Teesside Area*)	
N.E. COAST—	£ s. d.	£ s. d.
Hematite Mixed Nos.	3 8 6	3 0 0
No. 1	3 9 0	3 1 0
Cleveland—	(*D/d Teesside Area*)	
No. 1	3 10 0	3 4 0
No. 3 G.M.B.	3 7 6	3 1 6
No. 4 Forge	3 6 6	3 0 6
Basic (*Less 5/– rebate*)	3 7 6	—
MIDLANDS—		
Staffs.—	(*Delivered to Black Country Station*)	
North Staffs. Foundry	3 11 0	—
„ „ Forge	3 6 6	—
Basic (*Less 5/– rebate*)	3 12 6	—
Northampton—		
Foundry No. 3	3 7 6	—
Forge	3 2 6	—
Derbyshire—		
No. 3 Foundry	3 11 0	—
Forge	3 6 0	—
SCOTLAND—		
Hematite, f.o.t. furnaces	3 11 0	—
No. 1 Foundry, ditto	3 12 6	—
No. 3 Foundry, ditto	3 10 0	—
Basic, d/d (*Less 5/– rebate*)	3 7 6	—
N.W. COAST—		
Hematite Mixed Nos.	3 12 6 d/d Glasgow 4 0 6 „ Sheffield 4 5 6 „ Birmingham	

MANUFACTURED IRON.

	Home.	Export.
LANCS.—	£ s. d.	£ s. d.
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
S. YORKS.—		
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
MIDLANDS—		
Crown Bars	9 15 0	—
Marked Bars (Staffs.)	12 0 0	—
Nut and Bolt Bars	7 5 0 to 7 15 0	—
SCOTLAND—		
Crown Bars	9 12 6	9 5 0
Best	10 2 6	9 15 0
N.E. COAST—		
Common Bars	9 12 6	8 15 0
Best Bars	10 2 6	9 15 0
Double Best Bars	10 12 6	10 0 0

STEEL.

	Home.	Export.
LONDON AND THE SOUTH—	£ s. d.	£ s. d.
Angles	8 10 0	7 7 6
Tees	9 10 0	8 7 6
Joists	8 17 6	7 7 6
Channels	8 15 0	7 12 6
Rounds, 3in. and up	9 10 0	8 7 6
„ under 3in.	8 14 6	—
Flats, 5in. and under	8 14 6	7 2 6
Plates, ¾in. (basis)	9 0 0	7 15 0
„ 7/16in.	9 5 0	8 0 0
„ ½in.	9 10 0	8 5 0
„ 7/16in.	9 15 0	8 10 0
„ ⅜in.	9 10 0	8 5 0
NORTH-EAST COAST—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Plates, ¾in.	8 15 0	7 15 0
„ 7/16in.	9 0 0	8 0 0
„ ½in.	9 5 0	8 5 0
„ 7/16in.	9 10 0	8 10 0
„ ⅜in.	9 5 0	8 5 0
Boiler Plates, ¾in.	9 5 0	8 5 0
MIDLANDS, AND LEEDS AND DISTRICT—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¾in. (basis)	8 17 6	7 15 0
„ 7/16in.	9 2 6	8 0 0
„ ½in.	9 7 6	8 5 0
„ 7/16in.	9 12 6	8 10 0
„ ⅜in.	9 5 0	8 5 0
Boiler Plates, ¾in.	9 7 6	7 15 0 to 8 5 0

STEEL (*continued*).

	Home.	Export.
GLASGOW AND DISTRICT—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¾in. (basis)	8 15 0	7 15 0
„ 7/16in.	9 0 0	8 0 0
„ ½in.	9 5 0	8 5 0
„ 7/16in.	9 10 0	8 10 0
„ ⅜in.	9 5 0	8 5 0
Boiler Plates	9 5 0	8 5 0
SOUTH WALES AREA—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 0
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¾in. (basis)	8 17 6	7 15 0
„ 7/16in.	9 2 6	8 0 0
„ ½in.	9 7 6	8 5 0
„ 7/16in.	9 12 6	8 10 0
„ ⅜in.	9 10 0	8 5 0

IRELAND—	BELFAST. £ s. d.	REST OF IRELAND. £ s. d.
Angles	8 12 6	8 15 0
Tees	9 12 6	9 15 0
Joists	9 0 0	9 2 6
Channels	8 17 6	9 0 0
Rounds, 3in. and up	9 12 6	9 15 0
„ under 3in.	9 2 0	9 4 6
Plates, ¾in. (basis)	9 0 0	9 2 6
„ 7/16in.	9 5 0	9 7 6
„ ½in.	9 10 0	9 12 6
„ 7/16in.	9 15 0	9 17 6
„ ⅜in.	9 12 6	9 15 0

OTHER STEEL MATERIALS.

	Home.	Export.
Sheets.	£ s. d.	£ s. d.
10-G. to 13-G., f.o.r.	9 0 0	8 15 0
14-G. to 20-G., d/d	10 5 0	9 0 0
21-G. to 24-G., d/d	10 10 0	9 5 0
25-G. to 27-G., d/d	11 2 6	9 17 6

The above home trade prices are for 4-ton lots and over; 2-ton to 4-ton lots, 10s. per ton extra; and under 2-ton lots, 30s. per ton extra.

Galvanised Corrugated Sheets, Basis 24-G.

Home.	£ s. d.
4-ton lots and up	13 0 0
2-ton to 4-ton lots	13 7 6
Under 2 tons	15 0 0

Export: £16 12s. 6d., c.i.f. duty paid India.
„ £11 5s. 0d., f.o.b. other markets.
„ Scandinavian Markets free.

Tin-plates.
20 by 14 basis, f.o.b. Bristol Channel ports, 18/2.
Tin-plate Bars, d/d South Wales Works, £5 7s. 6d.

Billets.	£ s. d.
Basic (0·33% to 0·41% C.)	6 12 6
„ Medium (0·42% to 0·60% C.)	7 2 6
„ Hard (0·61% to 0·85% C.)	7 12 6
„ „ (0·86% to 0·99% C.)	8 2 6
„ „ (1% C. and up)	8 12 6
Soft (up to 0·25% C.), 500 tons and up	5 10 0
100 tons	5 15 0
Rails, Heavy, 500-ton lots, f.o.t.	8 10 0
„ Light, f.o.t.	7 10 0

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	3/3 per lb.	
Ferro Tungsten	3/– per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£23 0 0	7/–
„ „ 6 p.c. to 8 p.c.	£21 12 6	7/–
„ „ 8 p.c. to 10 p.c.	£21 12 6	7/–
„ „ Specially Refined		
„ „ Max. 2 p.c. carbon	£34 0 0	11/–
„ „ „ 1 p.c. carbon	£38 15 0	12/–
„ „ „ 0·70 p.c. carbon	£42 0 0	12/6
„ „ „ carbon free	10d. per lb.	
Metallic Chromium	2/5 per lb.	
Ferro Manganese (loose)	£10 5 0 home	
„ Silicon, 45 p.c. to 50 p.c.	£13 0 0 scale	5/– p.u.
„ „ 75 p.c.	£18 7 6 scale	6/– p.u.
„ Vanadium	12/8 per lb.	
„ Molybdenum	5/3 per lb.	
„ Titanium (carbon free)	9d. per lb.	
Nickel (per ton)	£200 to £205	
Ferro Cobalt	5/3d. per lb.	

NON-FERROUS METALS.

Official Prices, December 5th.

COPPER—	
Cash	£27 3 9 to £27 5 0
Three months	£27 11 3 to £27 12 6
Electrolytic	£30 10 0 to £30 15 0
Best Selected Ingots, d/d Birmingham	£30 10 0
Sheets, Hot Rolled	£58 0 0
	Home. Export.
Tubes, Solid Drawn (basis)	9½d. 9½d.
„ Brazed (basis)	9½d. 9½d.
BRASS—	
Ingots, 70/30, d/d Birmingham	£27 0 0 to £29 0 0
	Home. Export.
Tubes, Solid Drawn, 2/1 Alloy	8¾d. 8¾d.
„ Brazed	10¾d. 10¾d.
TIN—	
Cash	£228 7 6 to £228 10 0
Three months	£228 15 0 to £228 17 6
LEAD:	£10 6 3 to £10 11 3
SPELTER:	£11 16 3 to £12 2 6
Aluminium Ingots (British)	£100

FUELS.

SCOTLAND.

	Export.
LANARKSHIRE—	
(f.o.b. Grangemouth)—Navigation Unscreened	13/– to 13/6
„ Glasgow—Ell	15/6
„ „ Splint	16/6 to 17/–
AYRSHIRE—	
(f.o.b. Ports)—Steam	13/–
FIFESHIRE—	
(f.o.b. Methil or Burntisland)—Prime Steam	13/6 to 14/–
Unscreened Navigation	12/6 to 13/–
LOTHIANS—	
(f.o.b. Leith)—Hartley Prime	13/3 to 13/6
Secondary Steam	13/–

ENGLAND.

YORKSHIRE, MANCHESTER—	
B.S.Y. Hard Steams	18/6 to 21/6
Furnace Coke	13/– to 17/6
NORTHUMBERLAND, NEWCASTLE—	
Blyth Best	14/3 to 14/6
„ Second	13/– to 13/3
„ Best Small	10/6 to 11/–
Unscreened	12/6 to 13/6
DURHAM—	
Best Gas	14/8
Foundry Coke	18/6 to 22/6

SHEFFIELD	Inland.	
Best Hand-picked Branch	24/– to 26/–	—
South Yorkshire Best	21/– to 23/–	—
South Yorkshire Seconds	17/6 to 19/–	—
Rough Slacks	8/– to 9/–	—
Nutty Slacks	7/– to 8/6	—

SOUTH WALES.

CARDIFF—	
Steam Coals:	
Best Admiralty Large	19/6
Seconds	19/– to 19/4½
Best Dry Large	18/9 to 19/3
Ordinaries	18/3 to 18/6
Best Bunker Smalls	13/6 to 14/–
Cargo Smalls	11/6 to 12/6
Dry Nuts	22/– to 26/–
Foundry Coke	24/– to 37/6
Furnace Coke	19/– to 21/6
Patent Fuel	21/–
SWANSEA—	
Anthracite Coals:	
Best Large	37/6 to 40/–
Machine-made Cobbles	41/– to 51/–
Nuts	40/– to 50/–
Beans	25/– to 30/–
Peas	19/– to 22/6
Rubbly Culm	11/6 to 12/–
Steam Coals:	
Large	17/– to 20/6

FUEL OIL.

Inland consumption; contracts in bulk.
Exclusive of Government tax of 1d. per gallon.

Ex Ocean Installation.	Per Gallon.
Furnace Oil (0·950 gravity)	3½d.
Diesel Oil	4d.

Manchester prices ¼d. per gallon extra.

French Engineering Notes.

(From our own Correspondent in Paris.)

The New Trade Policy.

THE new policy directed toward an industrial recovery, outlined by Monsieur Flandin, President of the Council, has met with a favourable reception, because it appears to offer the only means of extricating the country from a dangerous situation arising, in part, out of expermental measures that were intended to protect home industries from the worst effects of the world slump. The plan aims at nursing trade and industry back to a state at which it can be relieved of restrictions. The nursing implies an adaptation of industry to new conditions. There must be equilibrium between production and consumption, and charges on industrial and other producers must be lessened by reduced taxation, lower railway rates, and economies in distributing services, so that goods and products may be sold more cheaply and consumption thereby increased. A commission of experts will be appointed to operate only in times of industrial crisis, and its duty will be to advise the Government on matters relating to production. Industrial groups will be invited to regulate output in accordance with the recommendations of the commission, and the Government will take measures to ensure that the plans for reduced output adopted by any group will not be frustrated by the refusal of a minority to join in them. When there is no longer any necessity to regulate production the work of the commission will be suspended. There is no illusion about the possibility of recovering all the foreign trade that has been lost, and more attention is therefore being centred on an organised system of colonial development in the belief that the colonies will offer a steady and improving market for French manufactured goods. At the same time, negotiations with foreign countries for trade facilities on a reciprocal basis will be carried out more actively, and it is in this direction that tangible results can be obtained, depending upon concessions which the French are prepared to make.

Shipping.

The loss of 195,777,000f. on the year's working of the Compagnie Générale Transatlantique, and the forebodings that marked the debate on the budget estimates for the merchant marine, reveal that there is no change for the better in shipping, notwithstanding the increased tonnage in service following upon the operations of the subsidy scheme. The State subvention of 150 million francs reduces the above-named loss by that amount, and the situation of the company has been improved by a reorganisation of subsidiary lines which are now giving better results. The new fast ship which will reduce the time of the journey between Marseilles and Algiers to less than twenty hours will be put into service in July next. It is confirmed that the " Normandie " will start on her maiden voyage to New York in May, and during the debate on the budget it was argued that the State should make good any financial deficit from the running of the giant ship. The country is quite prepared to make sacrifices for merchant shipping, but there is an impression that what has been done so far has failed to achieve the object of the subsidy scheme. It is true that more tonnage is in service and, in a general way, the situation has apparently improved, but much of the laid-up tonnage released by the subsidy consists of old vessels that should have been broken up. It is claimed that the subsidy is prolonging the agony of an inefficient section of the fleet. Moreover, it is by no means certain that the State will be able to pay the full amount of 140 million francs to be raised by a tax on imports. On account of import restrictions it is estimated that the amount available for subsidies this year will not exceed 90 millions, so that the situation of shipowners who are running old vessels with the aid of this State contribution is precarious. The subsidy is, in fact, intended to help the fleet through an extremely difficult period, first in order to provide employment for officers and seamen and then to enable owners to modernise their ships. But shipowners complain that the cost of building ships in French yards is far too high. The Government decree issued last year to the effect that the big shipyards must amalgamate in their respective centres with a view to economy, and that State orders will be withheld from small yards, has been attacked on the ground of illegality by those builders who will have to close down, and pending the decision of the Conseil d'Etat the Government is declared to have settled upon a plan for the rationalisation of the industry which will remove objections. The chief cause of the lamentable situation of shipping is the difficulty of competing for freights which are governed by dollar and sterling currencies. Until there is some stabilisation of the world's monetary systems shipowners are looking to a monopoly of the growing colonial traffic, as well as to the granting of some import licences preferably for goods carried on French bottoms.

Canal Haulage.

The conditions of canal haulage provide a perpetual source of recrimination because railway competition is limiting the categories of goods that can be profitably sent by water, and freights have fallen so low that acceleration of services has become indispensable if anything is to be made out of the business. The motor barge can accomplish two return journeys between Lens and Paris to one by the hauled barge. The Office National de Navigation has no interest in favouring motor barges at the expense of the State electric haulage equipment, and it must, moreover, protect the interests of those who employ electric haulage, while there are traffic considerations that limit the number of barges. On the canals in the Est which are not electrified the Office National proposes to make mechanical haulage compulsory for all, but the Metz Chamber of Commerce objects to this course being adopted, except experimentally, and then only on condition that barges are hauled individually by tugs that will be available when required. Such an arrangement would obviously give to the hauled barge the same acceleration as the motor barge. A regulation requiring the suppression of two ordinary barges when a motor barge is put in service is causing dissatisfaction amongst builders.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgement is not illustrated the Specification is without drawings.

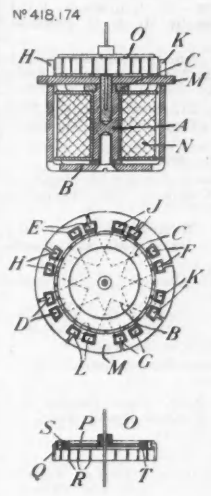
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgement, is the date of the acceptance of the complete Specification.

DYNAMOS AND MOTORS.

418,174. March 22nd, 1934.—SMALL SELF-STARTING SYNCHRONOUS ELECTRIC MOTOR, Landis and Gyr A.-G., of Hofstrasse 1, Zug, Switzerland.

By means of the invention an improvement in small synchronous motors having stators with more than two split poles is obtained, more especially with regard to the starting torque.

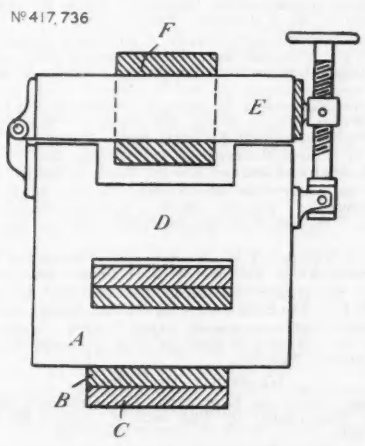


The magnet system of the synchronous motor comprises an iron core A, with cross-shaped pole pieces B C respectively. The four divided poles D E F G and H J K L respectively of the pole pieces B C extend through slots in a copper ring M. The slots are opened near one limb or member of each of the divided poles D to L by a slit, whereby two fluxes displaced relatively to one another in phase are produced, such fluxes together forming an eight-pole rotary field. The exciting coil N connected to the supply mains is mounted on the iron core A. The rotor O, shown separately, comprises a cap-shaped member P, the peripheral flange or part Q of which has narrow slits R. On each side of the disc part of this cap-shaped member P there is a copper ring S T connected together by copper rivets. By reason of the phase displacement of the fluxes generated, an eight-pole elliptical rotary field is produced. This rotary field induces in the squirrel-cage winding currents which cause the rotor to start. As the speed increases the slip becomes less, and consequently the rotor currents decrease. By reason of the high hysteresis there remains, however, a certain driving torque which finally brings the rotor into synchronous rotation. When the rotor has reached synchronous rotation, magnet poles are formed in it and remain unaltered in position by reason of the narrow slits in the rotor, whereby the synchronous running of the rotor is maintained.—*October 19th*, 1934.

TRANSFORMERS AND CONVERTERS.

417,736. November 17th, 1933.—ELECTRIC TRANSFORMERS, *The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C.2.*

This invention is concerned with electric transformers with magnetic leakage paths, such as are of particular service in connection with electric arc welding, and an arrangement is described for adjusting the air gaps. The ferro-magnetic core A carries at B and C the primary and secondary windings arranged like those of a normal transformer, with magnetic leakages, which are as low as possible. The part of the core D serves as return for the corresponding flux, whilst the core E carries a winding F which is inserted preferably in the primary

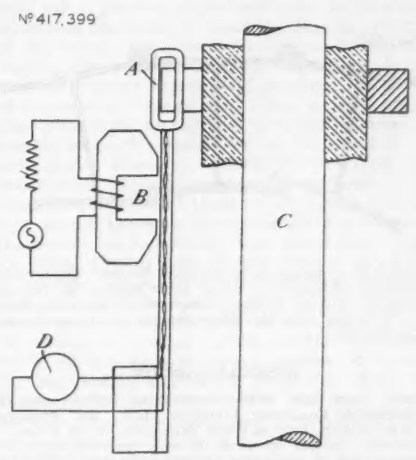


circuit, its flux path being closed likewise by the core D. In order to regulate progressively the self-inductance of winding F, the core E is mounted on a hinge which allows it to be moved to or from the core D by means of a screw device operated by a hand wheel. Thus a reactance coil with variable air gap is obtained and the permanent insertion of this in the primary or secondary circuit allows the intensity of the welding current to be modified as desired. Moreover, if the reluctance of the limb D is not negligible, a certain mutual induction can be created between the winding F and the windings B and C, so that when necessary, means are available for adjusting on the value of the secondary no-load voltage.—*October 11th*, 1934.

MEASURING AND TESTING INSTRUMENTS.

417,399. May 5th, 1933.—ARRANGEMENTS FOR MEASURING CURRENT IN DIRECT-CURRENT ELECTRIC CIRCUITS, Brian Andrew Graham Churcher, of Richmond, Langham-road, Bowdon, Chester, and Associated Electrical Industries, Ltd., of Crown House, Aldwych, Westminster.

An arrangement is described in this specification for measuring the current flowing in a direct-current electrical conductor, more particularly a high-voltage conductor. The current-carrying conductor is surrounded at one point along its length by a relatively stationary magnetic core, which is electrically insulated from the conductor and is provided with one or more air gaps in which is disposed a coil which is subjected to continuous oscillatory or rotational movement at substantially constant frequency. The resultant electromotive force induced in the coil is detected and utilised to provide a measure of the current flowing through the conductor at any particular time. In operation, the Coil A, oscillated at substantially constant frequency under the action of the impulsing electro-

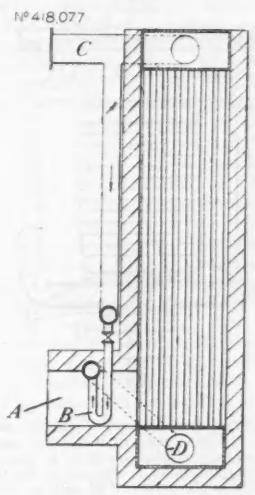


magnet B, will have induced in it an electromotive force which will be dependent upon the strength of the field linking the conductor C, and which can be detected by the voltmeter D, thereby to give a measure of the value of current which is flowing in the conductor C.—*October 4th*, 1934.

FURNACES.

418,077. August 5th, 1933.—HEATING SURFACES FOR RECUPERATORS, Rekuperator, Gesellschaft mit beschränkter Haftung, 53, Hindenburgwall, Düsseldorf, Germany.

In recuperators for preheating the air used in furnaces by means of the waste gases there is danger of the tubes of the recuperator being damaged by heat radiated from the brickwork of the gas inlet passage A, which may reach a temperature

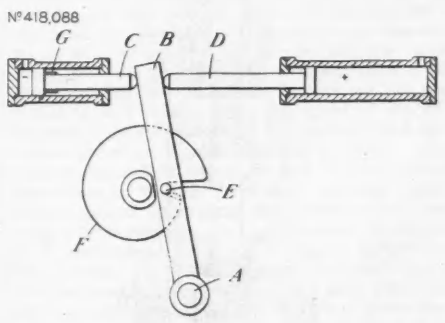


as high as 1200 deg. Cent. According to the invention, this radiation is screened off by the auxiliary recuperator B through which about 10 per cent. of the air supplied at C is by-passed. This very hot air is then mixed with the preheated air at the main outlet D. The temperature of the tubes of the main recuperator does not rise much above 800 deg. Cent. The auxiliary recuperator is easily replaceable.—*October 18th*, 1934.

MACHINE TOOLS AND SHOP APPLIANCES.

418,088. November 4th, 1933.—QUICK APPROACH FEED GEARS ON LATHES, A. Drummond, Ryde's Hill, Guildford.

The object of this invention is to bring the tool quickly up to its work, then feed it forward at a comparatively slow speed, and finally to withdraw it abruptly. The tool slide is actuated by the shaft A, on which the lever B is keyed. The upper end of the lever is engaged by the two hydraulic rams C and D, while a roller E engages a cam F. The parts are shown in the



drawing in the position with the tool withdrawn and the roller E lying in the bottom of a notch in the cam. When the cut is to be started fluid pressure is admitted behind the ram C and pushes the roller out of the notch in the cam. The continuance of this movement is stopped by the collar G and at the same moment a trip gear starts the cam rotating. The cam then effects the cutting feed, working in opposition to the pressure in the ram cylinder D. When the highest part of the cam has passed the roller, the tool is rapidly withdrawn by the pressure on the ram D.—*October 18th*, 1934.

BUILDING.

417,560. March 3rd, 1934.—SHEET PILING, Dortmund-Hoerder Hüttenverein Aktiengesellschaft, Dortmund, Germany.

It is explained that it is difficult to drive the piles of cofferdams of small diameter when they are made of I sections on

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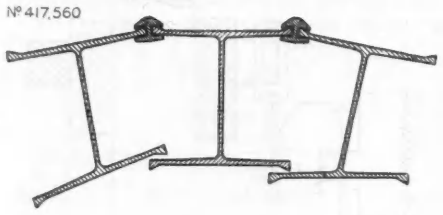

account of the interference of the inner flanges. The inventors consequently deliberately distort these flanges, so that they may overlap and use locking connections on the outer flanges only. They say that the latter practice is advantageous.—*October 8th*, 1934.

MISCELLANEOUS.

417,395. April 5th, 1933.—ELECTRICAL CONDENSERS, The Telegraph Condenser Company, Ltd., and Humphrey William Cole, both of Wales Farm-road, North Acton.

According to this invention a container enclosing a condenser or bank of condensers is made of insulating material of sufficient strength to afford the necessary reaction to the thrust of a screw or equivalent clamping means. Since metal does not enter into the construction of the container, its walls may be brought within a short distance of, or even bear on the condenser or bank of condensers, so that the bulk of each unit is very considerably reduced as no air space or insulation is required between the condenser and its casing. The condenser or bank of condensers A is provided at its opposite ends with metal plates B, which serve as terminals, and the plate in proximity to the closed end of the container is fitted with a threaded stud C, and provided with a clamping nut D, whereby,

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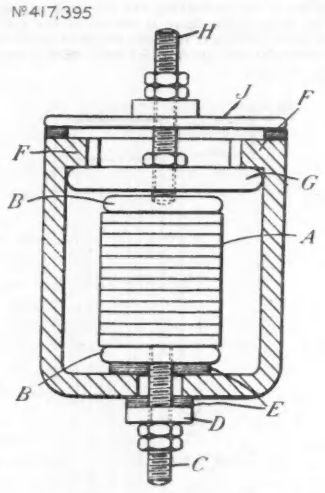

with the intervention, if necessary, of suitable gaskets E, the metal plate B is firmly secured to the closed end of the container. At the open end the container is formed with two inwardly directed projections F adapted to be engaged by a plate G inserted from the open end in such a position as to be clear of the projections F, and then rotated so as to engage their inner surfaces as shown. Screwed through the plate G is a stud H adapted to bear on the terminal plate B in proximity to the open end of the container. Thus, by rotating this stud, pressure may be exerted on the condenser or bank of condensers C, the plate G serving for this purpose as an abutment. The container may then be filled with a suitable insulating material, which remains liquid at ordinary temperatures, or with materials, such as wax, which will solidify on cooling. If desired, the open end of the container may be covered by means of a disc J.—*October 4th*, 1934.

417,780. June 19th, 1934.—PARALLEL SLIDE VALVES, R. G. Lawson, Dalston-road, Workington, Cumberland.

In this valve the two discs A and B are pressed on to their seatings, when it is closed, by the usual style of spring C. They

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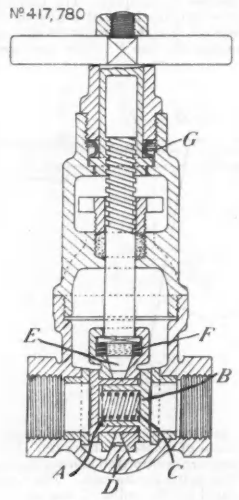


are also forced apart and against their seatings by the wedges D and E when the spindle is screwed hard down. Springs at F and G allow for expansion and contraction with changes of temperature.—*October 11th*, 1934.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

BELFAST ASSOC. OF ENGINEERS.—Queen's Hotel, Belfast. Smoking concert. 8 p.m.

INST. OF MECHANICAL ENGINEERS.—Storey's-gate, S.W.1. Informal meeting. 7 p.m.

INST. OF STRUCTURAL ENGINEERS: WESTERN COUNTIES BRANCH.—At Merchant Venturers' Technical College, Bristol. "The Code of Practice for the Use of Reinforced Concrete in Buildings," Mr. G. B. R. Pimm. 7.15 p.m.

JUNIOR INST. OF ENGINEERS.—39, Victoria-street, S.W.1. "Geometrical Constants," Dr. W. N. Bond. 7.30 p.m.

NORTHAMPTON POLYTECHNIC INST.—St. John-street, E.C.1. Annual prize distribution. Address by Mr. C. C. Paterson. 7 p.m.

PHYSICAL SOC.—Imperial College of Science and Technology, S.W.7. Editing Committee meeting, 3.30 p.m.; Council meeting, 4 p.m.; meeting, 4.45 for 5 p.m.

ROYAL INST. OF GREAT BRITAIN.—21, Albemarle-street, W.1, Discourse, "The Crystallisation of Alloys," Dr. C. H. Desch. F.R.S. 9 p.m.

SATURDAY, DEC. 8TH.

INST. OF ELECTRICAL ENGINEERS: LONDON STUDENTS.—Visit to works of British Oxygen Company, Ltd., Edmonton. 10 a.m.

INST. OF ELECTRICAL ENGINEERS: N. MIDLAND STUDENTS.—Visit to works of John Fowler and Co. (Leeds), Ltd., Leeds. 2.30 p.m.

INST. OF MARINE ENGINEERS.—The Minories, E.C.3. Junior Section social and dance. 7.30 p.m.

NORTHAMPTON ENGINEERING COLLEGE PAST DAY STUDENTS' ASSOC. ("OLD N'IONS").—Criterion Restaurant, Piccadilly, W.1. Thirteenth annual dinner. 7.30 p.m. for 8 p.m.

NORTHAMPTON POLYTECHNIC INST.—St. John-street, E.C.1. Annual conversazione, 6.30 to 11 p.m.

STEPHENSON LOCOMOTIVE SOC.—King's Cross Station, N.1. Annual general meeting, 3 p.m., Midland Grand Hotel, St. Pancras, N.W.1. Annual dinner, 6.30 p.m.

MONDAY, DEC. 10TH.

CHADWICK PUBLIC LECTURES.—London School of Hygiene, Keppel-street, Gower-street, W.C.1. "Men and Masses," Dr. F. R. Seymour. 5.30 p.m.

CHARTERED SURVEYORS' INST.—12, Great George-street, S.W.1. "The National Water Supply," Mr. A. E. L. Chorlton. 6.30 p.m.

INST. OF CIVIL ENGINEERS: BELFAST AND DISTRICT ASSOC.—Physics Lecture Theatre, Queen's University, Belfast. "Asphalt Road Construction," Mr. E. A. Dalzell. 6.30 p.m.

INST. OF ELECTRICAL ENGINEERS: N. EASTERN CENTRE.—Armstrong College, Newcastle-upon-Tyne. "Generation, Distribution, and Use of Electricity on Board Ship," Messrs. C. W. Saunders, and H. W. Wilson, and Dr. R. G. Jakeman. 7 p.m.

INST. OF METALS: SCOTTISH LOCAL SECTION.—At 39, Elmbank-crescent, Glasgow. "Improvements in Surface Condenser Tubes," Mr. A. Spittle. 7.30 p.m.

TUESDAY, DEC. 11TH.

ILLUMINATING ENG'G SOC.—At Inst. of Mechanical Engineers, Storey's-gate, S.W.1. "Flood-lighting by Gas," Mr. H. E. Bloor. 6.30 p.m. for 7 p.m.

INST. OF AUTOMOBILE ENGINEERS.—King's Head Hotel, Coventry. "Electric Discharge Lamps and the Application to Road Lighting," Messrs. H. Warren and L. J. Davies. 7.30 p.m.

INST. OF BRITISH FOUNDRYMEN: BURNLEY SECTION.—Municipal College, Ormerod-street, Burnley. "Points for Practical Foundrymen," Mr. A. Jackson. 7.15 p.m.

INST. OF ELECTRICAL ENGINEERS: S. MIDLANDS' STUDENTS.—James Watt Memorial Inst., Birmingham. "Analysis and Measurement of Noise from Machinery." Mr. C. A. Mason. 7 p.m.

INST. OF ELECTRICAL ENGINEERS: SCOTTISH CENTRE.—North British Station Hotel, Edinburgh. "The Pithead Generating Station," Prof. Francis G. Baily. 7 p.m.

INST. OF MARINE ENGINEERS.—The Minories, E.C. "Gears for Marine Main and Auxiliary Drives," Dr. H. E. Merritt. 6 p.m.

INST. OF STRUCTURAL ENGINEERS: SOUTH WALES AND MONMOUTHSHIRE BRANCH.—Baltic Lounge, Castle-street, Swansea. "Suitable Structures for Power Stations," Mr. Rees. 7 p.m.

INST. OF METALS.—Y.M.C.A., Swansea. "Refractory Materials of South Wales," Professor W. R. D. Jones. 6.15 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, W.1. "The Solid State," Sir William Bragg. 5.15 p.m.

SHEFFIELD METALLURGICAL ASSOC.—198, West-street, Sheffield, 1. "Testing of Steels at High Temperatures," Mr. W. E. Bargett. 7.30 p.m.

WEDNESDAY, DEC. 12TH.

BELFAST ASSOC. OF ENGINEERS.—Queen's Hotel, Belfast. "Power Transmission by Flat and 'V' Belts," Mr. S. B. Hainsworth.

INST. OF CIVIL ENGINEERS.—Great George-street, S.W.1. Informal meeting. Discussion, "Modern Developments in Variable Transmission Gears," Dr. H. S. Hele-Shaw. 6 p.m.

INST. OF MECHANICAL ENGINEERS.—Graduates' visit to Cadby Hall of J. Lyons and Co., Ltd.

INST. OF STRUCTURAL ENGINEERS: LANCASHIRE AND CHESHIRE BRANCH.—College of Technology, Manchester. "Welding as Applied to Structural Steelwork," Mr. A. R. Moon. 7 p.m.

TELEVISION SOC.—At University College, Gower-street, W.C.1. "Elementary Theory of Electron Optics," Dr. N. C. Martin. 7 p.m.

THURSDAY, DEC. 13TH.

INST. OF CIVIL ENGINEERS: BIRMINGHAM AND DISTRICT ASSOC.—Queen's Hotel, Birmingham. Annual dinner. 6.30 for 7 p.m.

INST. OF LOCOMOTIVE ENGINEERS.—At Inst. of Mechanical Engineers, Storey's-gate, S.W.1. Informal meeting. 6 p.m.

INST. OF STRUCTURAL ENGINEERS.—10, Upper Belgrave-street, S.W.1. "The Code of Practice for Reinforced Concrete," Mr. C. E. Reynolds. 6.30 p.m.

ROYAL AERONAUTICAL SOC.—At Royal Society of Arts, John-street, Adelphi, W.C.2. "Recent Research in Metallurgy," Dr. W. H. Hatfield. 6.30 p.m.

FRIDAY, DEC. 14TH.

CHEMICAL ENGINEERING GROUP.—Rooms of Chemical Soc., Burlington House, W.1. "Chemical Aspect of Timber Research," Mr. W. G. Campbell. 8 p.m.

INST. OF ELECTRICAL ENGINEERS: S. MIDLAND STUDENTS.—Boot's Café, Colmore-row, Birmingham. Annual dance.

INST. OF MECHANICAL ENGINEERS.—Storey's-gate, S.W.1. "Air Swirl in Oil Engines," J. F. Alcock. 6 p.m.

INST. OF METALS: SHEFFIELD.—The University, St. George's-square, Sheffield. "Rhodium Plating and its Application," Mr. A. W. Scott. 7.30 p.m.

JUNIOR INST. OF ENGINEERS.—At Royal Soc. of Arts, John-street, Adelphi, W.C.2. Inaugural meeting, "The Lighting of Streets and Roadways, with special Reference to Safety," Mr. C. C. Paterson. 7.30 p.m.

N. EAST COAST INST. OF ENGINEERS AND SHIPBUILDERS.—Mining Inst., Newcastle-upon-Tyne. "Production in Engineering Works," Mr. J. C. Green. 6 p.m.

ROYAL SOC. OF ARTS.—John-street, Adelphi, W.C.2.—"Indian Forestry: Economic and Commercial Aspects," Mr. A. D. Blascheck. 4.30 p.m.

FRIDAY AND SATURDAY, DEC. 14TH AND 15TH.

BOROUGH POLYTECHNIC.—Borough-road, S.E.1. Exhibition of Students' Works. Friday, 6–9 p.m.; Saturday, 2.30 to 9.30 p.m.

SATURDAY, DEC. 15TH.

INST. OF CIVIL ENGINEERS: STUDENTS.—Visit to Building Research Station, near Watford.

INST. OF METALS: N. EAST COAST LOCAL SECTION.—Joint meeting with Inst. of British Foundrymen. Armstrong College, Newcastle-upon-Tyne. "Problems in Non-ferrous Foundry Practice," Mr. F. W. Howe. 7.30 p.m.

MANCHESTER ASSOC. OF ENGINEERS.—At College of Technology, Manchester. Conversazione and dance. 6.45 to 11.30 p.m.

MONDAY, DEC. 17TH.

INST. OF MECHANICAL ENGINEERS: GRADUATES.—Joint meeting with Inst. of Electrical Engineers, London Students. Storey's-gate, S.W.1. "Overhaul of Electric Railway Stock," Mr. E. McEwen. 6.15 for 6.45 p.m.

INST. OF STRUCTURAL ENGINEERS: MIDLAND COUNTIES BRANCH.—James Watt Memorial Inst., Birmingham. "The Maintenance and Repair of Small Highway Bridges," Mr. J. H. N. Wilkes. 6.30 p.m.

WOLVERHAMPTON AND DISTRICT ENGINEERING SOC.—Victoria Hotel, Wolverhampton. "The Commercial Production of Oxygen and Hydrogen by Electrolysis of Water," Mr. A. E. Knowles. 7.30 p.m.

TUESDAY, DEC. 18TH.

CHEMICAL ENGINEERING GROUP.—Hotel Great Central, Marylebone, W. Annual Chemical Dinner.

CRYSTAL PALACE SCHOOL OF PRACTICAL ENGINEERING.—186th award of certificates. Chairman, Mr. H. C. Adams. 3 p.m.

INST. OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—39, Elmbank-crescent, Glasgow, C.2. "A New Type of Marine Steam Engine," Mr. G. R. Grange. 7.30 p.m.

INST. OF METALS: BIRMINGHAM LOCAL SECTION.—James Watt Memorial Inst., Birmingham. "Interpretation of the Equilibrium Diagram," Dr. N. P. Allen. 7 p.m.

INST. OF STRUCTURAL ENGINEERS: SCOTTISH BRANCH.—At 15, Rutland-square, Edinburgh. "Examination of Welded Joint," Mr. T. S. Glover. 7.15 p.m.

SHEFFIELD METALLURGICAL ASSOC.—198, West-street, Sheffield, 1. "X-ray Examination of Metals, with some Results," Dr. P. Jay. 7.30 p.m.

WEDNESDAY, DEC. 19TH.

INST. OF AUTOMOBILE ENGINEERS.—Hotel Metropole, Leeds. "Functions of Mechanical Power in Soil Cultivation," Dr. B. A. Keen; "Some Features of Modern Tractor Design," Mr. S. J. Wright. 7.15 p.m.

INST. OF AUTOMOBILE ENGINEERS.—Engineers' Club, Manchester. "Electric Discharge Lamps and their Application to Road Lighting," Messrs. H. Warren and L. J. Davies. 7 p.m.

INST. OF CHEMICAL ENGINEERS.—In Rooms of Chemical Soc., Burlington House, W.1. "Separation of Solids from Liquids (Thickening)," Dr. Wm. Cullen and Mr. H. T. Durant. 6 p.m.

THURSDAY, DEC. 20TH.

INST. OF MARINE ENGINEERS: JUNIOR SECTION.—The Minories, E.C. "The Production of Aluminium and some of its Applications to Marine Engineering," Mr. G. A. Anderson. 7 p.m.

INST. OF STRUCTURAL ENGINEERS.—10, Upper Belgrave-street, S.W.1. Ordinary general meeting for election of members. 6.30 p.m.

FRIDAY, DEC. 21ST.

ELECTRO-DEPOSITORS' TECHNICAL SOC.—James Watt Memorial Inst., Birmingham. "Barrel Plating Technique," Mr. E. J. Dobbs. 7.30 p.m.

INST. OF BRITISH FOUNDRYMEN: JUNIOR SECTION.—College of Technology, Sackville-street, Manchester. "Cupola Practice," Mr. J. Jackson. 7.30 p.m.

JUNIOR INST. OF ENGINEERS.—39, Victoria-street, S.W.1. Lecture, "Regulations and Rules Affecting Luminous Discharge Tube Installations." 7.30 p.m.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

ROLLS-ROYCE, Ltd., ask us to announce that Lieut.-Colonel M. Ormonde Darby has been appointed aero sales manager in succession to the late H. E. Pooley.

SPECIALLOID LTD. announces that Mr. Henry Patterson Bone, 65, Whirlowdale-road, Sheffield, has been appointed representative for the Argentine, Brazil, and Uruguay.

MR. JAMES EWART TAGGART has been appointed by the Government of the Punjab, Executive Engineer in the Electricity Branch of the Punjab Public Works Department.

MR. E. R. BRIGGS, M. Inst. C.E., M.I. Mech. E., for many years at the Rugby works (formerly Willans and Robinson, Ltd.) of the company, has severed his connection with the English Electric Company, Ltd.

A FIRE occurred in the premises of the Euston Manufacturing Company, Ltd., of 143B, Euston-road, N.W.1, on Thursday evening, November 29th. Considerable damage was done to the building, plant and stock. We are asked to say that the company is doing everything possible to attend to orders already on hand, and with temporary accommodation will quickly be able to resume operations.

NEW CONSTRUCTION IN BRITISH AND CONTINENTAL YARDS.—We have just received from our contemporary, the *Journal of Commerce*, a useful little booklet bound in limp linen covers, which gives a complete list of the steamers and motor ships now on order in British shipbuilding yards and the yards on the Continent. The yard number of many of the British-built ships are given, and in the Continental section the countries are arranged in alphabetical order. As the entries are made on the left-hand side of the page only, there is room on the facing page for further notes, &c. The editions of the booklet are issued three or four times during each year and can be obtained from the Publisher, the *Journal of Commerce, Shipbuilding and Engineering Edition*, Liverpool, 2, post free one shilling.

A Seven-Day Journal

Warship Names and Contracts.

THE Admiralty announces that it has been decided to name all the 9000-ton cruisers after towns. In the 1933 programme the Vickers Tyne-built cruiser will be the "Newcastle" and the John Brown cruiser the "Southampton," which will replace the "Minotaur" as the class name for vessels of this type. Of the 1934 programme the following cruisers have been ordered:—The "Glasgow," to be built by Scotts, of Greenock; the "Sheffield," by Vickers, on the Tyne; and the "Birmingham," at Devonport Dockyard. Of the thirty vessels under the 1934 programme, orders for eleven have been already placed and five are to be constructed at the Royal Dockyards. In the near future, therefore, orders must be allocated for the following fourteen ships:—The aircraft carrier "Ark Royal," the two submarines the "Rorqual" and "Spearfish," the four sloops "Niger," "Salamander," "Mallard," and "Puffin," the net layer "Protector," the surveying ship "Stork," the boom gate vessels "Dowgate" and "Ludgate," the boom working vessel "Dunnet," the submarine school tender "Dwarf," and the trawler "Basset." When these orders have been placed it is estimated that the number of firms engaged upon major contracts for the Admiralty will be higher than at any time since the conclusion of the war programmes. The work involved will not only bring assistance to the heavy steel and coal industries, but will be spread over a wide area of trade in the engineering and allied industries.

The Smithfield Club Show.

As is our usual custom, we have made a tour of the Smithfield Club's Annual Cattle Show, which closes to-day, the 14th, at the Royal Agricultural Hall, Islington, and found that, as has been the case during the past few years, there is little of interest for the mechanical engineer. It seems a strange state of affairs, seeing that from thirty to twenty years ago, when farming was mostly carried on by animal power, there was always a good display of machinery at the Show; now, in what is generally described as "the mechanised age," the engineer should be almost exclusively represented by what may be unkindly described as blacksmith's work. Certainly cream separators, milking machines, and refrigerators are of a higher order, but harrows, rakes, ploughs, and manure distributors cannot raise much enthusiasm in the breast of an engineer; while the complete absence of the steam engine in any form whatever, and the very modest show of oil and petrol engines is disappointing. It is more or less understandable that the steam engine has gone into the background, as it has been developed to a high degree of perfection. But it is still made in considerable numbers, although the makers suffer from the loss of their Continental markets; consequently, there is not much inducement for them to display their wares. On the other hand, the internal combustion engine is still in a state of evolution, and improvements are effected year by year, so that one would expect a competitive display of this form of prime mover. Finally, there is no indication that the electric motor, with the "grid" system of power distribution behind it, is being taken very seriously, either by the farmers or our agricultural engineers. With cattle pens, chicken runs, and wire fencing, which are displayed among the heavier implements, it is not our province to deal, and we can only say that were financial affairs in better order just now, our agricultural engineers could put up a much more interesting display.

Steam Road Vehicles.

ON Wednesday, December 12th, an influential deputation, organised by the Coal Utilisation Council, and representative of the Mining Association, coal merchants, and traders, and both makers and users of steam road vehicles, waited on the Minister of Transport at the House of Commons and presented a memorandum dealing with the present position of the steam-propelled vehicle and its possible future. The object of the deputation was to draw the attention of Mr. Hore-Belisha to the position in which the steam road vehicle has been placed by the regulations limiting its weight when laden. The deputation urged the expediency in national interest of so revising the regulations governing the operation of steam road vehicles that their use and development may be encouraged rather than discouraged. The steam vehicle was, it was claimed, important as an employer of British labour, as every thousand such vehicles on the road would keep 650 men employed in their own villages for a whole year. In 1931 there were about 6507 vehicles licenced, but in 1934 the number fell to 2430, representing a loss in coal consumption of over 400,000 tons per annum. The deputation pointed out that the steam vehicle must carry 20 cwt. of fuel, and in order to permit it to carry the same pay load as other vehicles, an addition of 2 tons to its gross load should be allowed. In the application of the existing regulations the steam vehicle was, it was suggested, often suspected, and was more subject to delays by weighing and examination than were other vehicles of similar weight. The effect of the regulations on users was shown by extracts from letters. It was pointed out that there was only one firm still manufacturing and marketing steam road vehicles, and as a direct result of the difficulties imposed by legislation, its trade in spares and repairs had decreased by 70 per cent., and its sales were now less than the average of one per week. The deputation urgently prayed the Minister to reconsider the weight restriction in order to allow all four-wheeled steam vehicles on pneumatic tires to carry 14 tons at speeds up to 20 miles per hour, and all six-wheeled vehicles to carry 21 tons with a corresponding increase in axle loads. An assurance was requested that there was no official bias against the steam vehicle.

The Industrial Welfare Society.

THE annual meeting of the Industrial Welfare Society (Incorporated) took place at 14, Hobart-place, S.W.1, on Tuesday afternoon, December 11th, and was attended by the President, the Duke of York. His Royal Highness expressed the belief that the sails of industry were more squarely set and better filled than they had been for some time, and thus employers were finding themselves in an easier position to deal with those questions in which the society was interested. In the absence of Lord Invernairn the chair was taken by Mr. Seebohm Rowntree. Lord Invernairn's speech was read by the secretary, in it he referred to the appreciation shown by members of the additional services the Society had to offer, and of the increase in its membership. The rapid extension of the welfare movement had proved, Lord Invernairn said, that it was sound policy to give heed to the human side of industry. A remarkable interest in the welfare movement was being shown by other industrial countries, and he felt that the responsibility for maintaining the Society in the strongest possible position was one which should be recognised by those who had not yet helped in its work. It could be fairly claimed that most of the large industrial organisations in Great Britain were taking an active interest in the Society's work, but the smaller firms had not yet, he thought, fully realised the value of its services. The Society was well equipped to give such firms full information on any activity, however simple, that they might contemplate introducing as a part of their administration. If by joining the Society the slightest injury was prevented from becoming septic, the labour turnover reduced by almost a negligible percentage, or one accident obviated, then the very nominal subscription that membership entailed would be more than covered.

The Orient Liner Orion.

WE attended a launch of unusual interest at the Barrow-in-Furness yard of Vickers-Armstrongs, Ltd., on Friday last, December 7th, when the new 24,000 gross ton liner "Orion," which is being constructed for the Australian service of the Orient Steam Navigation Company, Ltd., was actually released from her launching ways by means of a wireless impulse transmitted from Australia, which operated through relay apparatus. The launch was made from Brisbane, Australia, by His Royal Highness the Duke of Gloucester. Sir Alan Anderson, the chairman of the Orient Line, speaking from Australia, said that the new liner was the sixth of her class to be built during the last ten years. She would cost more than £1,000,000, and would give employment to at least 5000 men for one year in several industries. The launching ceremony was broadcast in Great Britain, and in Australia and New Zealand. The "Orion" is an enlarged "Orontes," with a length of 665ft., a beam of 82ft., and a draught of 30ft. She has a 200ft. long sports deck, the full width of the ship, which will be unbroken, except for the uptakes for the single funnel and the engine-room hatch. The fire-protection equipment includes an installation of Grinnell sprinklers, which were fitted and under pressure at the time of the launch. The propelling machinery comprises a twin-screw arrangement of single-reduction geared turbines, taking steam at 425 lb. pressure from Babcock and Wilcox water-tube boilers, made at Barrow. The designed output of the turbines is about 24,000 s.h.p., corresponding to a speed of about 21½ knots. The "Orion" is expected to be completed next summer, when she will make an August cruise before starting on her maiden voyage to Australia at the end of September.

Research on Water Supplies.

IN the annual report of the Water Pollution Research Board, publishedon Monday, December 10th, by the Department of Scientific and Industrial Research, reference is made to the exceptional conditions of weather during 1933 and 1934. The long spell of dry weather not only caused difficulties in the provision of ample quantities of water for various purposes, but had a serious detrimental effect on the quality of the water in rivers and streams into which sewage and trade effluents are discharged, as less water than usual was available for dilution of the discharges. At the present time, the report points out, there are many undertakings utilising polluted river water, after treatment, for domestic and industrial supplies, and there is no doubt that other polluted rivers will have to be similarly utilised in the future to meet the increasing demands of the community. It is important, therefore, that further efforts should be made to prevent, as far as possible without unnecessary expense, the pollution of rivers and streams and other sources of water supply if expensive methods of water treatment and danger to public health are to be avoided. This necessitates intensive, systematic research, as in many cases entirely satisfactory methods of treatment and disposal of trade effluents at a reasonable cost are not known. The investigations initiated by the Board deal respectively with purification of water for public supply, methods of treatment and disposal of sewage, methods of treatment and disposal of trade effluents and various problems of river pollution. Many experiments have been carried out on the effects of various factors on the treatment of water by the base exchange process of softening. Further experiments on the treatment of the waste waters discharged from dairies and milk products factories have been made, and considerable progress has been made in fundamental investigations into the biological and chemical factors entering into methods of sewage purification. At the present time the Board is engaged on an extensive survey of the amount of material deposited and the character of the deposit in the Mersey Estuary. This work is being carried out at the request of Merseyside local authorities and the Mersey Docks and Harbour Board.

The Clyde Passenger Steamer King George V.

WE are informed that the Clyde passenger steamer "King George V" is to be re-equipped with double-ended 200 lb. pressure marine boilers, which will replace her present 550 lb. pressure water-tube boilers. The turbine arrangement will be altered in such a way that the shaft horse-power of the propelling machinery will not be lowered. The reason given for the change is that the Scotch boiler is believed to be more convenient than the water-tube boiler for the particular Firth of Clyde passenger service in which the "King George V" is engaged. The ship was built, it will be recalled, in 1926 by William Denny and Brothers, of Dumbarton, and engined by the Parsons Marine Steam Turbine Company, Ltd., of Wallsend, to the order of Turbine Steamers, Ltd., of Glasgow. Her design introduced the most advanced proposals of the late Sir Charles Parsons with regard to the increased thermal efficiency to be obtained by the use of higher steam pressures and temperatures. The service results obtained fully justified the great inventor's theories, paving the way for present-day advances in the use of high-pressure and high-temperature marine steam plants. The high-pressure turbine installed in the "King George V" to utilise the expansion of the steam from 550 lb. down to 200 lb., will, we understand, be taken out, thus leaving two intermediate-pressure turbines, and one low-pressure turbine on each shaft. This alteration is to be carried out immediately, so that the ship will be ready for the next season of Clyde passenger service. A full description of the original machinery was given in our issue of September 10th, 1926.

Speed Economics.

IN the course of an address given by Sir Josiah Stamp at the annual dinner of the Warrington Chamber of Commerce, an interesting statement was made on the cost of speed and its experimental determination. He said that he was more concerned in the economics of speed, and refused to be excited by an additional acceleration until he knew the relative cost of obtaining it and what sacrifices there might be of other amenities of comfort and of safety. In the case of some of the aircraft now operated by Railway Air Services, an increase of 20 per cent. of speed would involve an all-in increase of at least 40 per cent. in operating costs. When they came to the sea, similar factors applied, and if it was wished to accelerate the speed of one of the company's latest vessels by 20 per cent., the cost of fuel alone would be increased 100 per cent. On the railway, the L.M.S. had in the last two or three years specialised in raising the general average speed of expresses, and comparing the figures with those of 1914, there was an average increase in speed of 10·2 per cent. The question of still higher speeds was having his constant attention, and he gave detailed particulars of some recent tests made under service conditions. The comparison of these results with the costs of increments in speed obtained from oil engine locomotives, &c., would give them in due course the basis of much important planning for the future. The practical economic problem of running a fast train, however, went much further than the costs of the physical performance, and involved commercial considerations, such as the traffic affected or deflected from other trains, with sometimes surprising repercussions.

The New Fish Dock, Grimsby.

No. II.

(*Concluded from page 561, December 7th.*)

DOCK QUAYS.

DURING the progress of the work difficulties encountered, owing to the soft and treacherous nature of the ground, necessitated reconsideration of the design of the internal quays, and new designs for these and for the dock jetties were prepared. These alterations and the modified type of construction adopted caused a delay of several months in carrying out the work.

The main, or North Quay, about 2000ft. long, running parallel to the river embankment, is intended to provide accommodation for trawlers, after they have discharged their cargoes of fish at the markets, when taking in stores, ice, &c., and for minor repair work, while the quay on the south side, 690ft. long, will be used for general outfitting in conjunction with the two jetties equipped with cranes for this work. Both quays are of similar design, and are constructed in reinforced concrete. A cross section of the North Quay is reproduced in Fig. 14, and views of the work in progress in Figs. 15 and 13 (*ante*). The open-work structures are 75ft. wide, the front 50ft. being used as the quay and the back portion carrying a 25ft. roadway. The excavation in the dry was limited to a slope of approximately 3 to 1 from the face of the quays, so that the piles could be driven in level, undisturbed ground. After the structures had been finished and water admitted to the dock the banks were dredged out. The quays are supported on reinforced concrete piles at 12ft. 6in. centre to centre in both directions, cut off above the original foreshore level, and the superstructure of columns, walings and decking built up on them. Along the back of the quays there is a row of Larssen No. 3 steel sheet piling with a reinforced concrete slab, 9in. thick, above to retain the filling behind, the depth of filling from foreshore level to quay level being about 13ft., and the concrete piles at the back, which are of lengths up to 55ft., are driven to a rake of 1 in 3 to take the forward earth pressure. The deck of the quay is surfaced with 2in. granolithic and the roadway with 2½in. "Carpave."

A chalk bank of varying width was tipped behind the quays, and the filling, consisting of excavated material from the dock, completed. The fendering for the quays is of pitch pine throughout; bollards are fixed every 25ft. along the quays, and 3in. diameter hydrants are provided and served from a main carried on brackets attached to the 9in. slab at the back of the quays.

In spite of the precautions taken for dealing with the soft ground, it was found that, when the filling behind the North Quay had been almost completed, there was a gradual forward movement of the quay taking place, this movement being at its maximum at the lock entrance end, where the ground is very bad. The structure began to show signs of stress at the pile caps and in the retaining slab. It was to be expected that further forward movement would take place when the bank in front of the quay was dredged away, and it was therefore decided to tie back the whole structure as quickly as possible to the river embankment, this being the only stable anchorage available. A waling formed of two 24in. by 7½in. steel joists was first laid under the quay in front of the steel sheeting and back pile beam and tied back at every 37ft. 6in. along the length of the quay to anchorages formed in the river embankment, as shown in the cross section, Fig. 4 (*ante*).

Each of the anchor ties consists of two 6in. by 1½in. flat steel bars connected at the quay end by two 3½in. bolts to the longitudinal beam and at the embankment end by similar bolts to anchor curtains of steel piling driven in the chalk embankment. After the ties had been placed in position and tightened up the bank left in front of the quay was partially excavated by hand, in the dry, as shown in the section. This was done to relieve the pressure of the ground on the piles. Since the dredging has been completed a further slight forward movement of the quay has been noted, owing to the stretching of the long ties.

The North Quay superstructure contains about 250,000 cubic feet of concrete, 1000 tons of steel reinforcement and is carried on 1304 piles. The South Quay contains 77,000 cubic feet of concrete, 330 tons of steel reinforcement, and is carried on 420 piles. No movement of the South Quay, though of similar construction to the North Quay, has taken place.

WEST QUAY.

Although the West Quay, seen in the middle distance, Fig. 2 (*ante*), will only be used as a berthing place for trawlers waiting to go on the slipways, it was necessary to build some kind of structure to retain as large a bank as possible between the existing graving docks and the new dock during construction to ensure against any break through of water. The construction was made more difficult by the proximity of the work to the existing access road to Campbell's Jetty, which was in use throughout the greater part of the contract. Under this road were electric mains, hydraulic and water pipes, and alongside it was laid the contractors' track to the lock entrance, all of which services had to be maintained. A row of No. 5 Larssen steel sheet piling in 50ft. lengths was first driven along the face line of the quay, part of the piling being anchored back to a raking pile and beam and slab anchorage, the remainder being held by 3½in. diameter tie bolts to a continuous anchorage built along the back of the existing Campbell's Jetty. The fendering consists of vertical timber piles driven close to the steel sheeting with a floating boom attached to the piles by wire ropes.

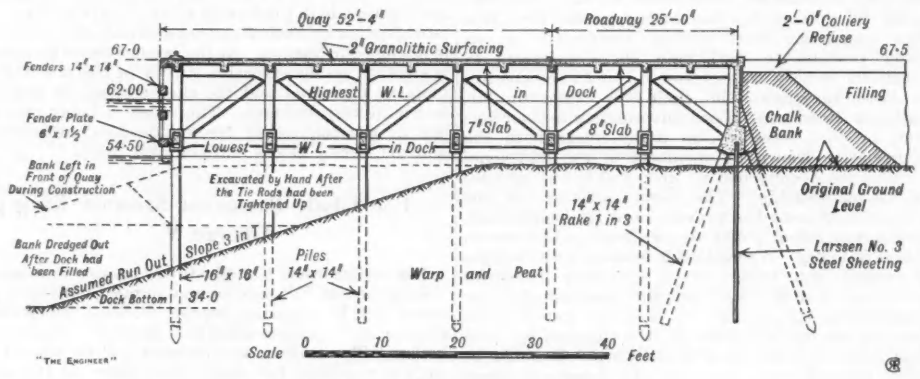


FIG. 14—CROSS SECTION OF NORTH QUAY

EAST QUAY.

The east side of the dock forms the base from which the coaling jetties project into the dock, and it was originally intended to form a pitched slope of 1 in 2 extending from dock bottom to the finished ground level. The ground, however, proved to be too soft to stand at this angle and a slope of 1 in 3 was adopted from dock bottom up to the original foreshore level and above this the filling is retained by reinforced concrete sheet piling with a beam and slab and raking pile anchorage, also constructed in reinforced concrete. The concrete sheet piling is 12in. thick and is tongued and grooved. The length of this quay is 526ft. and a similar construction at its north end, parallel to the North Quay, is about 210ft. long. In these two works there are about 18,200 cubic feet of concrete and 71 tons of steel reinforcement in the beams, slab and retaining wall, with 153 14in. square raking piles and 572 sheet piles.

OUTFITTING JETTIES.

The necessity for providing a central roadway along each of the two outfitting jetties of sufficient width to allow lorries to pass each other decided the main dimensions and design of these structures. The jetties, seen in the left foreground, Fig. 2 (*ante*), are of reinforced concrete construction and each has an overall width of 41ft. 2in. with a central roadway 21ft. wide between kerbs to give lorries carrying material to and from the cranes room to pass each other. The crane rails are carried on 12in. by 6in. pitch pine bearers at 26ft. centre to centre, and the crane portals give a clear headroom of 14ft. The excavation having been completed over the site of the jetties, the 14in. square reinforced concrete piles were driven by a frame at dock bottom and were cut off at a height of 24ft. above the ground. The shuttering for the columns, walings, beams, and decking was then fixed near the top of the piles and the reinforced concrete superstructure built up on them. To strengthen the structures against side blows from trawlers, reinforced concrete surrounds were built round the groups of piles at each frame at dock bottom level with diagonal braces from them to the junction of the piles with the superstructure. The deck of the shorter jetty is of heavy construction to take two vehicles, each capable of carrying a 15 tons load to the crane. The electric travelling portal crane, built by John M. Henderson and Co., Ltd., Aberdeen, has a working load of 15 tons at a maximum radius of 50ft. The crane on the long jetty is of a similar type with a working load of 5 tons and was built by Cowans, Sheldon and Co., Ltd., Carlisle. In both jetties concrete pits with suitable covers are built below deck level containing electric supply plugs for the crane, for welding and for lighting, while several fresh water hydrants are also provided. The short jetty is 268ft. long and the longer jetty 398ft.; the superstructures contain 54,300 cubic feet of concrete, 220 tons of steel reinforcement, and the number of piles is 253.

TRAWLER SLIPWAYS.

The slipway yard at the south end of the dock provides for the underwater repair, cleaning, and painting of trawlers. The three slipways are constructed on the system patented by Mr. Archibald Henderson, M. Inst. C.E., of Henderson and Nicol, Aberdeen, who was responsible for the design of the machinery. The east slipway, serving two side berths, is designed to take trawlers up to 160ft. between perpendiculars, and weighing, when fully loaded with coal, ice, and stores, up to 1080 tons. The centre slipway serves two, and the west three side berths, and both are designed to take trawlers light or partially loaded up to 660 tons. Each slipway with its side berths and machinery forms a complete unit by itself, independent of the others. When a ship is to be slipped, the articulated cradle is lowered down the main slipway (which has a slope of 1 in 14·75), and the ship centred over it, after which both are pulled up together, the ship gradually taking its bearing on the keel blocks and being pulled up out of the water. The slipway rails in the yard are in short lengths separated by nine gaps of about 10ft., and in these gaps run the traverser carriages on tracks laid at right angles to the slipway. These traverser carriages are fitted with rails which close the gaps between the short lengths of slipway rails, and when in register with them a continuous track is formed to the top of the yard, up which the slipway cradle

FIG. 15—NORTH QUAY—NOVEMBER, 1933

with the ship on it is hauled until all the cradle wheels are resting on the traverser carriages. The two sets are then locked together, the haulage ropes disconnected, and the ship, cradle, and traverser carriages all pulled sideways to one of the fixed berths, where, by means of hydraulic jacks and wedges, the ship is transferred to the fixed keel and bilge blocks. The traversers and cradles are then free to be pulled back again to repeat the operation on another ship, placing it on the fixed berth on the other side.

The foundations for the slipways and yard are all constructed in reinforced concrete, and are supported on 1624 concrete piles. The beams contain 135,000 cubic feet of concrete, reinforced with 400 tons of reinforcing steel, and there are 3350 cubic yards of mass concrete in the slipway, keel and bilge blocks in the floor of the yard and in the foundations of the main hauling winches.

The cradle and ship are hauled up the slipway by an electrically driven winch with two large diameter drums through two wire ropes. The hauling speed, in the case of the east slipway, is 10ft. per minute, and the lowering speed 40ft. per minute; the pull on each of the hauling ropes is 70 tons. Traversing at 9ft. per minute is effected by means of four chains attached to four of the traverser carriages, the chains passing over driving sprockets at one side of the yard driven through shafting by an electric motor, and returning through pipes laid below the floor to the other side of the yard and thence back to the traverser carriages. The drive for both hauling and traversing is effected through variable-speed gear. The contract for the appliances was let to P. and W. MacLellan, Ltd., of Glasgow, with John M. Henderson and Co., Ltd., of Aberdeen, as sub-contractors for the machinery work.

TRAWLER COALING APPLIANCES.

The three coaling jetties are situated on the east side of the dock, projecting from the east wharf to which reference has already been made. Each of the three coaling appliances (Fig. 16) can coal two ships at one time, and is designed to deliver a total of 240 tons of coal per hour. The wagons are hauled from the sidings by endless rope capstans and the coal tipped by a combined turntable and tipper into a 20-ton hopper, from which it is fed on to a 42in. belt conveyor. This conveyor, which runs through a tunnel under the roadway and then through a covered steel gantry, transports the coal to either of two 25-ton hoppers in the fixed coaling tower on the jetty. The foundation for this tower is of reinforced concrete (Fig. 17), with sixteen raking piles to secure stability in the soft strata which forms the dock bottom, while the rest of the jetty, alongside which the trawlers lie when being coaled, is of Oregon pine. The coaling tower is of steel construction and it carries two cantilever arms on each side at right angles to the jetty, reaching out over the trawlers and at a height of 70ft. above high water level, in order to clear the vessel's masts. Each of these cantilevers carries a 25-cwt. travelling bucket, with controlled bottom doors, which is filled with coal by an apron feeder from one of the hoppers, and is then hoisted and travelled out to either side of the ship. As trawler bunker hatches are too small to allow the bucket to pass through, the coal is dumped on deck and the coal trimmed into the bunkers by hand. The contractors for the coaling towers, gantries, hoppers, conveyors, and machinery are the Mitchell Conveyor and Transporter Company, Ltd. The two 2-ton capstans provided on each jetty to assist in berthing the trawlers have been supplied by Sir William Arrol and Co., Ltd., Glasgow, and the turntables and tipping gear by T. Broadbent and Sons, Ltd.

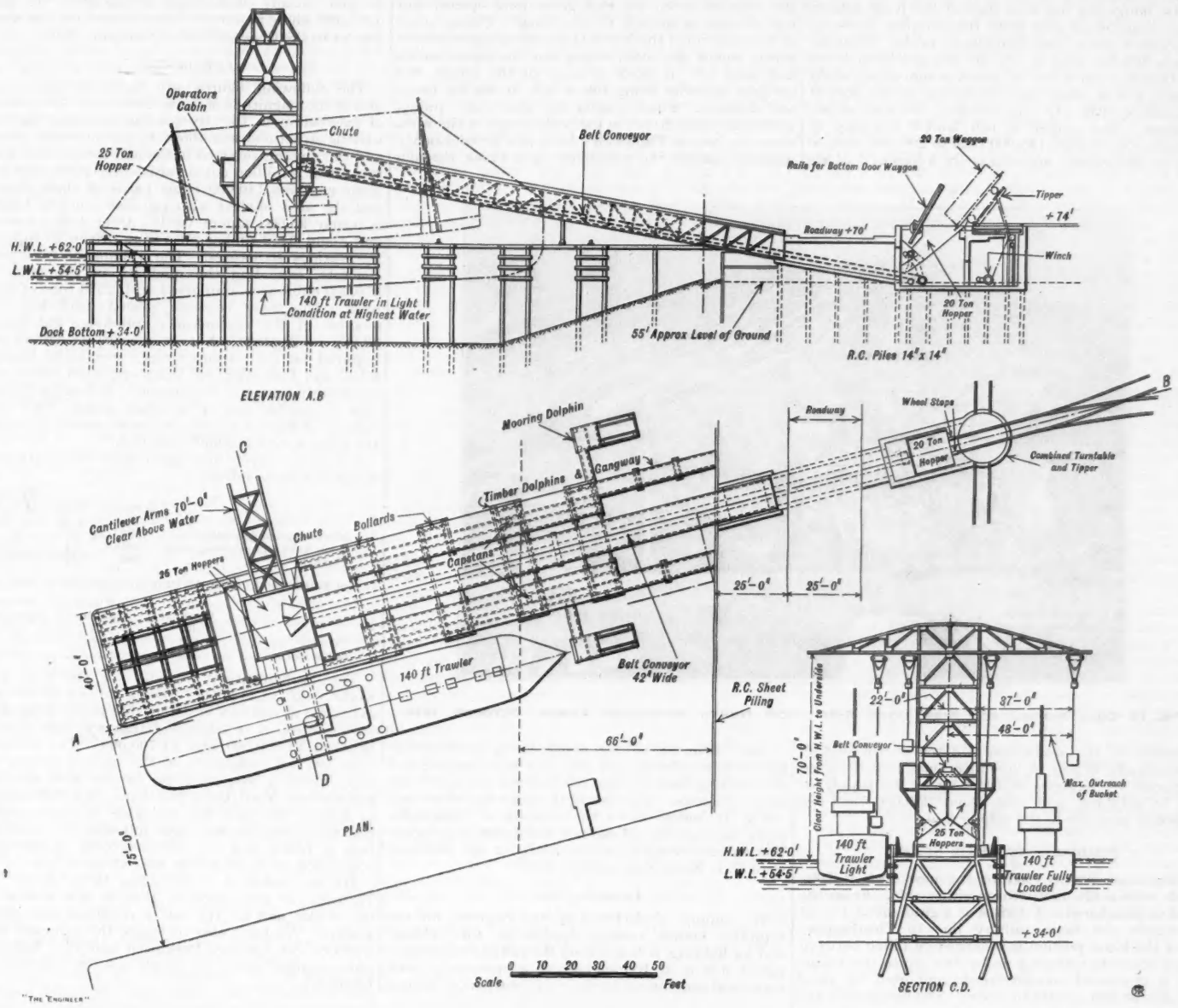


FIG. 16—TRAWLER COALING PLANT

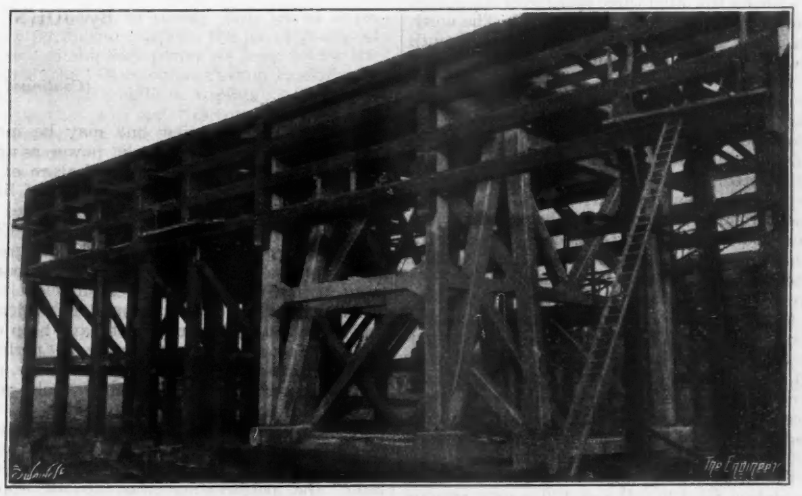


FIG. 17—ONE OF THE COALING JETTIES SHOWING REINFORCED CONCRETE FOUNDATION FOR BUNKERING TOWER

The average bunker capacity of Grimsby trawlers ranges from about 45 tons for North Sea vessels to about 225 tons in the case of trawlers engaged in the Iceland fishing. The tipping arrangements provide for coal wagons up to 20 tons capacity and for either end-tipping or bottom-door discharge. Apron

feeders are provided at all hoppers to minimise breakage of coal in passing on to the belts and into the travelling buckets. This interesting coal-bunkering plant, devised to meet the special needs of fishing craft, is undoubtedly a great improvement on the somewhat primitive arrangements for coaling trawlers hitherto available at Grimsby, where most of the bunkering has been carried out from lighters which transferred coal from the shipping hoists to the various fishing craft lying in the docks. Approximately 900,000 tons of coal are shipped annually in the Grimsby fish docks by trawlers and other fishing vessels, 628 of which were registered in the port at the end of 1933. Of this number, 506 were steam trawlers. The weight of fish landed annually at Grimsby varies from 185,000 tons to 200,000 tons, so that on the average approximately 5 tons of coal are required for the production of 1 ton of fish landed. Incidentally, it may be here mentioned that three ice factories are engaged at Grimsby in the supply of ice to shipping, and that about 250,000 tons are supplied annually to the fishing fleet.

FIG. 18—COAL SIDINGS FOR FISH DOCK SEEN FROM NORTH BUNKERING TOWER—OCTOBER, 1934

ROADWAYS AND RAIL SIDINGS.

The main access road to the new dock is 30ft. wide with a 6ft. footpath on either side. From the end of Humber-street it rises at a gradient of 1 in 25 alongside the main railway line to Cleethorpes; over the lower portion it is carried on filling between mass concrete retaining walls, then up to the bridge on a reinforced concrete deck supported by piled trestles at 20ft. centre to centre. The bridge over the railway consists of a series of five spans, each over two tracks, supported on piled trestles. The main beams were pre-cast up to ¼in. below the underside of the deck slab with the stirrups and top reinforcement left projecting, and were placed in position on the trestles by one of the railway company's break-down cranes. For the two south spans over running lines the shuttering for the deck slab was suspended from temporary timber trusses supported on the trestles, while for the other three spans over the sidings the shuttering was supported from below. The north approach is of similar construction to the south approach, and is 102ft. long from the north abutment of the bridge. From this point onwards the roadway and footpaths are carried on a bank of sand filling, the gradient again being 1 in 25 down to the dock roadways. The bridge and approaches contain 60,000 cubic feet of concrete reinforced with 380 tons of steel, and the number of 14in. square concrete piles which had to be driven is 279.

The new roadways, including those behind the North and South Quays and the access road over the bridge, have a total length of over 1 mile, and all are surfaced with "Carpave" surfacing.

The removal of, and alterations to, the existing sidings, together with the laying down of extensive new sidings, have been works of considerable magnitude in themselves. Over 1½ miles of track were removed, and about 1 mile slewed to new positions. In the new general sidings there are twenty-three tracks, each with an average length of about ¼ mile. The loaded coal sidings have an aggregate total length of over 8 miles, and the three groups of sidings serving the three coaling appliances, each providing accommodation for 120 full and 120 empty wagons, have a total length of track of over 4½ miles (Fig. 18).

DREDGING AND REMOVAL OF CAMPBELL'S JETTY.

When all the excavation to be done in the dry in the new dock area had been taken out and all the quays, jetties, and foundation structures completed, a start was made with the filling of the dock. The water was pumped from No. 1 Fish Dock by two 14in. electrically driven pumps through pipes laid over Campbell's Jetty, the pumps being started on January 26th, 1934. While the filling was going on a dredger had been dredging out the new entrance channel from the river up to the lock, the bed of the channel being at level +32·0ft., or 10ft. 6in. below M.L.W.S.T. When the water in the dock had reached the required level, the lock gates were opened and the dredger admitted to the dock. Commencing at the lock end of the North Quay the dredger worked slowly round the dock, taking out the banks which had been left in front of some of the quays, the dredged material being taken out to sea by barge and dumped. Finally, after the steel sheet piling, which had been driven in the early stages of the work along the back of Campbell's Jetty as a precautionary measure against the possibility of a break through of water from the old fish docks during construction, had been withdrawn, the old jetty was removed and the retaining bank dredged out, thereby uniting the old and new docks. The view of the inner end of the lock—Fig. 11 (*ante*)—shows the removal of Campbell's Jetty, between the old and new fish docks, in progress. The sub-contractors for the whole of the dredging were K. L. Kalis, Sons and Co., Ltd.

LIGHTING, &C.

The supply of electrical energy required for the slipways, cranes, coaling appliances, for welding, and for lighting, is taken from the railway company's power station at Immingham at a pressure of 6000 volts, and is delivered to three sub-stations, equipped by the Metropolitan-Vickers Electrical Company, Ltd., where the pressure is transformed down to 400 volts for power and welding, and to 230 volts for lighting. To enable work at the dock to be carried on throughout the twenty-four hours, the lighting has received special attention, and an external system of powerful flood-lights has been installed to give evenly distributed illumination of high intensity where required. The contract for this work was let to the General Electric Company, Ltd.

CONCLUSION.

The following figures will serve to give some idea of the magnitude of the undertaking. The volume of excavation in the dry for the dock and for the various structures was about 1¼ million cubic yards, and the amount dredged inside and outside the dock was about ¼ million cubic yards. The river embankment contains 140,000 cubic yards of chalk filling, and the area pitched with pre-cast concrete blocks is nearly 35,000 square yards. Over 4700 concrete and about 3450 timber piles were driven to support the various structures. The volume of reinforced concrete, excluding the quantity in the piles, is 670,000 cubic feet, reinforced with 2570 tons of steel rods. The mass concrete placed, excluding the amount in the embankment pitching, was about 39,000 cubic yards. A large quantity of timber was required for the various timber structures, bearing piles, and fendering, all being creosoted where not completely buried in the ground. As large a proportion as possible was of Canadian origin. The total volume of timber in the permanent works, including the piles, is over 310,000 cubic feet.

For mass concrete used in the work the proportions adopted were as follows:—

	Cement, lb.	Sand, c. ft.	Broken limestone, c. ft.
Mass concrete generally ..	204	9	20
Lock walls and pitching blocks	204	6¼	14½
Facings	204	3½	7½

For reinforced concrete two mixtures were used:

	Cement. lb.	Fine aggregate, c. ft.	Coarse aggregate, c. ft.
Piles	204	3¾	7½
Other work	204	5	10

The Parliamentary estimate for the new dock works was £1,418,000. Owing to additions and extensive alterations in design due to the difficulties encountered, it is estimated that the cost will be between £1,600,000 and £1,700,000. The contract time for the completion of the main contract was forty months, but, after the trouble with the lock foundations, North Quay and slopes occurred resulting in delays, this time was extended by nine months. Excellent progress was made following the modification of plans, and the contract work was actually completed six weeks within the extended time.

We are indebted to Sir John Wolfe Barry and Partners for permission to publish this account of the works, and for the use of drawings and photographs. We have also to thank the principal contractors, Sir Lindsay Parkinson and Co., Ltd., for photographs, most of which are by Burton, of Grimsby.

Machine Tools from the Works Manager's Point of View.

By JOHN HOLLOWAY, M.I. Mech. E.

No. III.

(*Continued from page 574, December 7th.*)

WHATEVER the view one may be inclined to take of electric-hydraulic power as applied to machine tools, it has become a feature of modern design that cannot be put aside as of little consequence. The many arresting examples seen at Olympia during the recent Machine Tool Exhibition all go to prove that although the progress made in hydraulic driving has not been particularly rapid, it has, nevertheless, been sufficient to compel serious attention. There is abundant evidence of the time, thought, and money that have been expanded by manufacturers in attempting to perfect what, even yet, must be considered a new drive, new, that is, in its application to machine tools, whether it be used for the main drive or for the feeds.

It has to be admitted that in every instance where the new drive was exhibited, whether on the grinding machine, the cold saw, the broaching machine, or the lathe, the performance was, to all appearances, perfect. Manipulation, either automatic or by hand, was extremely simple and reliable, while for smoothness of working and freedom from shock, the action was all that could be desired.

Undoubtedly there are further developments of machine tool drive by electric-hydraulic power well on the way. One gathered that impression when discussing with the manufacturers the probable lines on which advancement would be made. But already enough has been accomplished to compel the attention of the prospective buyer of machine tool plant, and the possibility of hydraulic power superseding electric and mechanical drives in the not distant future must be taken into account.

SELECTING MACHINE TOOL PLANT.

When selecting new plant the works manager is influenced by three or four major considerations, which can be summed up as "suitability," "efficiency," "reliability," "cost." All of these considerations are of equal importance, and each must be taken into account if disappointment with new plant is to be avoided; no matter what the nature of the drive may be. The ultimate deciding factor in making the selection is the overall cost of production of accurate work by the machine. We say "accurate" work, advisedly, because if the work produced is not accurate the machine would be too dear at any price.

Having first decided the most suitable type of machine for the work in hand, we shall then naturally look for the most efficient and reliable tool. If the work to be done is grinding, honing, broaching, or sawing, the claims of the hydraulic drive will have to be seriously considered, because for this class of work it has been more fully developed, and doubtless shows to more advantage, than in others. But should the new tools be wanted for straight turning, facing,

boring, or planing, the makers of hydraulic drives will have a more difficult task in competing with either the mechanical or electric drive, as in this branch of work the new drive does not appear to be so fully developed, while for screw-cutting—from the tool—it is admittedly at present not in the running, and therefore need not be considered.

But for whatever branch of work the new plant may be required, the advantages claimed for hydraulic driving should be carefully considered before reaching a decision. What the works manager wants to know when selecting new plant is the exact overall cost of the work that comes off the new machine, and before casting aside the well-tried mechanical or electric-mechanical drive, he will also want to know what exactly are the advantages claimed for the electric-hydraulic drive, and how the overall cost will be affected by adopting it.

ADVANTAGES CLAIMED FOR ELECTRIC-HYDRAULIC POWER.

Now without going into the merits of the different systems or designs of hydraulic power, we can examine broadly the claims made for the new drive, and endeavour to ascertain if they can be accepted as real advantages from the user's point of view. The first and perhaps the most important claim is that of infinite variety of speeds and feeds between maximum and zero. This claim, it can be said, is well founded; there are no steps or jumps in the range, the exact speed and feed required for the work in hand can be selected at will between the limits provided. But, after all, can this feature be considered so great an advantage, is every speed and feed between zero and maximum ever likely to be used on one machine? We think not, as already stated in a previous article. The work allocated to each machine is specific, and only requires a limited number of speeds and feeds to ensure maximum output; that is to say, only a given number can be used to advantage, and these can be quite easily arranged for mechanically, by means of change gears or friction drives. An instance comes to mind from the Exhibition. Capstan lathes were shown having only eight changes of speed, this being considered all that was necessary for the range of work the machine was suitable for. The infinite variety of speeds obtainable by the hydraulic drive is therefore unlikely to prove so attractive to the purchaser as some may have thought, since the advantage offered is questionable.

Another claim that is made is:—Freedom from breakdown owing to overrunning during self-acting operations. Again, it can be said the claim must be admitted, as the work table or saddle of the machine can be allowed to run up to a dead stop without damage to any part of the mechanism, the relief valves in the system taking care of the pressure and preventing it exceeding the predetermined level; running up to a dead stop also makes for increased accuracy of length in turning or milling, as well as for the positioning of form or gang tools. Precaution against overrunning, on mechanically operated machines, is provided by means of spring slip clutches and safety shearing pins. In this respect the hydraulic feed appears to have the advantage.

A great saving in tool upkeep cost is claimed for the hydraulic operation, and where it is applied to expensive broaching tools there is undoubtedly something to be said for it; the steady pull on the draw rod throughout a long stroke, coupled with the smooth, quick return, and the absence of anything in the nature of shock, will make for long life of the broach; indeed, the examples shown at the Exhibition were so successful that it marked the broaching machine as one direction in which hydraulic power is entirely justified; but we are not so sure of the saving in tool costs where it is applied to ordinary forming or gang tools, as the mechanically operated tool can be, and is, fed in just as steadily and regularly as it is when hydraulically operated. Hence, the saving in tool cost is not so apparent here.

When applied to the feed of surface and cylindrical grinding machines, hydraulic power proves quite suitable, at least, so far as the actual operation is concerned; there is no shock at the point of reverse, while the smoothness of traverse is beyond dispute. But here there is the objection of the dual drive:—electric-mechanical and electric-hydraulic-mechanical for driving the grinding wheel; hydraulic for feeds. In operation the combination works perfectly, but the initial cost is higher and this factor has to be considered. These remarks also apply to the electric-hydraulic turning lathe, a few examples of which were seen at the Exhibition. There is, however, even less justification for dual power on the medium size lathe than on the grinding machine. In the case of the grinder it is claimed that a perfectly smooth surface is obtained, and that there is freedom from anything like tooth marks which sometimes show on the ground surface when the machine is mechanically fed; that, however, is a moot point, and if it were the only claim that could be made for the application of hydraulic feeds and controls on grinding machines there would be little in it. But the strongest claim and the one that carries most conviction is the smoothness of traversing movements and freedom from shock at the point of reverse. This claim, for the grinder, at all events, can be freely admitted, and provided the hydraulic power unit is reliable over a long period, the repair cost should be small, while the life of the machine should be increased.

The claims made for electric-hydraulic power on lathes do not at present appear so well founded, though it must be admitted there are some points in its favour. The smaller the tool the more difficult it becomes to justify dual power; on the small and medium-sized machine every point is within easy reach; there are no distant points to which power has to be conveyed, and there is no legitimate reason why power should not be either all mechanical or all hydraulic; to have a mixture of both on this class of tool, whether it be centre lathe, chucking lathe, capstan or turret, not only makes it more complicated, but adds appreciably to the initial cost of the tool, so much so that many works managers will look askance at such a proposition.

When it becomes a question of choosing between mechanical power and hydraulic power for the machines we are discussing, one will consider the points of advantage each system has to offer, and these will be judged by the major considerations mentioned before, namely, suitability, efficiency, reliability, cost. Of these, suitability only affects the type of machine required for the job, and, therefore, will not enter into the comparison of the power systems. Again, cost, or price, of the tool is relative; it all depends on what is acquired for a given outlay; in other words, what one gets for his money. What really matters then, when selecting a machine tool, is efficiency and reliability.

Now, as every works manager and production engineer knows, the overall efficiency of a machine tool is not simple but complex; it cannot be expressed in terms of percentage, as that of an engine or compressor can be, but, as already indicated in the earlier part of this article, it is the overall efficiency—measured in terms of the ultimate cost of production—that counts. In arriving, then, at the overall efficiency of the tool, what must be taken into account is running cost, time taken for the operation expressed in terms of wages (including the time for putting on and taking off the machine), repairs, and depreciation. For general overheads or oncost, including any special tools required, it can be assumed this will be the same, whether the drive be mechanical or hydraulic. When these factors are known it is an easy matter to arrive at the overall efficiency of the machine. Then comes the question of reliability. Is the machine in every part of its mechanism to be relied on for continuous running? How much of its time will it be standing for repairs? Is it as efficient at the end of the day as at the beginning? To what degree is it subject to wear, and how soon will it become inaccurate? All these points have to be considered when making the choice of a drive.

In comparing the relative advantages of mechanical and hydraulic drives, both as regards main drive and feeds, there is a possibility that the well-known type—*i.e.*, the mechanical—may receive more favourable consideration than the less-known type—the hydraulic. We shall therefore endeavour to retain the open mind and review the several claims quite disinterestedly and dispassionately. Having no "axe" to grind that task will be comparatively easy. We have already indicated several types of machine tools in which the hydraulic drive scores an advantage. What we have to do now is to consider if the new drive can, with corresponding advantage, be applied to the type of tool coming under the general heading of "lathes." We would first of all mention—what every engineer knows—that the mechanically operated lathe is a well-tried servant, which has been gradually developed over a long period, until now we have a highly developed tool, capable of running noiselessly at high speeds to take full advantage of the improved cutting tools; high mechanical efficiency has been attained by the use of hardened and, in some instances, ground gear wheels, running in oil; while vibration has been almost entirely eliminated by placing the fast-running shafts in a low position on the headstock. In other cases noiseless running and quick change of speeds has been secured by the use of laminated friction plates, which for ease of operation and selection of the most suitable speed is a masterpiece of engineering science.

This, then, is roughly the type of mechanically operated tool the hydraulic engineer essays to compete with and improve upon. It is a stiff proposition. As we have already seen, success in a large measure has been attained with the application of hydraulic drive to speeds and feeds on some classes of machines, but it remains to be seen if it can be applied with equal success to the lathe. Many of the claims made for hydraulic power have already been reviewed, and so far as can be seen at present, no outstanding advantage can be shown for its inclusion in medium-sized lathe design. Some engineers have contended that hydraulic power should only be applied to the feeds of a machine, and not to the main drive; but although it is possible that this may hold good for heavy machines, there is no adequate reason why the dual drive should be applied to the small or medium-sized tool. With regard to efficiency, no case has been made out for its application to the lathe. The highest power efficiency that we know has yet been claimed for the hydraulic drive is 85 per cent., and even if that figure is accepted it does not appear to show any saving over the mechanically driven machine. When we come to examine the cost, we find the hydraulically operated machine admittedly higher in price, while it is very doubtful if the upkeep and repair costs will be as low as those of the purely mechanical machine. There is also the question of depreciation to be taken into account, and one will hardly expect to find the hydraulically operated machine carrying a lower depreciation figure. Thus, taking all the factors into account, it is difficult to see what there is to induce one to select a small or medium-sized machine with the new drive, especially when the machine comes within the category of lathes, and the works manager, looking for the highest all-round efficiency in his plant, will doubtless desire to have more convincing proof of improvement before he leaves the old for the new.

With the larger type of lathe, with heavy saddles and long beds there is no doubt more scope for the useful application of hydraulic power to feeds and motions.

(To be continued.)

A Survey of Ships and Engines.*

By LOUGHNAN ST. L. PENDRED, C.B.E., Hon. M.I. Mech. E. (Past-President).

(Concluded from page 571, December 7th.)

THE FUTURE.

HAVING now surveyed briefly, but, let us hope, sufficiently for our purpose, the development of the propulsion of ships by power we must follow the advice which the Bi-coloured-Python-Rock-Snake gave to the Elephant's child in Kipling's "Just So" story. Let us, that is to say, "devote ourselves to a little high tension," or this meandering will "vitiate our future career." We must leave the pleasant ground over which we have been ambling and endeavour to carry out the task adumbrated in the introduction. We will therefore lay down some of the elements of progress in curves and see whither they lead us.

Fig. 1 is a curve for coal consumptions between 1820 and 1934. You will observe that it still has a slight downward tendency, so that still lower consumptions may be looked for. Below is a pair of curves, one of which shows steam pressures, the other steam temperatures. You will note that steam pressures advanced up to 200 lb. per square inch, and then turned off towards the horizontal at a maximum of about 250 lb. per square inch. Then after 1920 they went up again to over 300 lb. per square inch and the shape of the curve suggests a further increase, possibly ending between 400 lb. and 450 lb. per square inch.

The temperature curve, for a time, follows the pressure curve, saturated steam being employed, but superheating is gradually making its way, even for reciprocating engines, and the curve is ascending. We may venture to prophesy that before many years have passed 1000 deg. Fah. total temperature will not be uncommon.

Fig. 2 is a curve of the speeds of ships, excluding war vessels, but including all others over 100 tons gross. This curve is based on figures extracted from

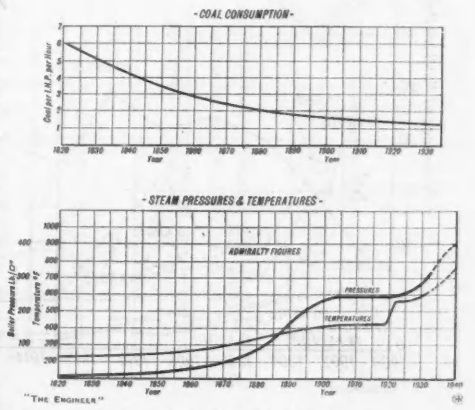


FIG. 1—COAL CONSUMPTION AND STEAM CONDITIONS FROM 1820 ONWARDS

Lloyd's Register. The base is speed; the ordinates are numbers of ships built in each year. The results for three separate groups of years are shown. You will note that slow-speed vessels, as one would expect, are in an enormous preponderance, but the general tendency of the lines is interesting. I have ventured

* Excerpts from the Seventh Thomas Lowe Gray Lecture. The Institution of Mechanical Engineers, November 30th.

to thread smoothed-out fancy curves through the points. They may not be the most accurate curves, but however wrong they may be in detail they show at any rate a tendency and that is all we are concerned with. The position of the curves is partly due to numbers, and the displacement to the right is not caused entirely by a general increase of speeds. The curves are interesting, but it would be dangerous to labour them too far, for they are based on "samples," not comprehensive figures, which unfortunately are not available. But the fact that smooth curves can be drawn through the points indicates that the samples are reasonably representative.

So an attempt is made to analyse them in another way in Fig. 3. Here the base is years and the ordinates numbers of ships built, by percentages. You will observe the general movement of the lines—the fall in the percentages of 12-knot ships during the past ten years; the rise in 15 and 18-knot ships and so on. Note how the position of the ships between 12 and 15 knots is declining whilst all the higher

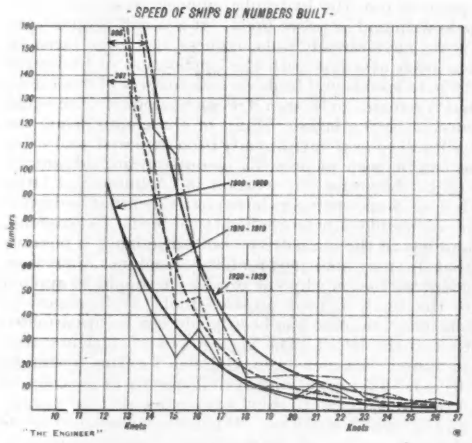


FIG. 2—NUMBER OF SHIPS OF DIFFERENT SPEEDS BUILT IN THREE DECADES

speeds are becoming larger percentages of the total. Is it not fairly safe to say from these diagrams that a general increase of speed is taking place and will continue?

In the curve in Fig. 4, showing gross tons afloat, we are on positive ground. All existing vessels over 100 tons registered by Lloyd's are included. You will at once be struck by three very patent facts. First, that up to 1931 the total tonnage of reciprocating steam vessels was practically constant, but was a long way ahead of the turbine and the oil engine. You will observe also that the steam turbine shows no upward inclination; there is no indication that its competition with the reciprocator is increasing. Now turn to the oil engine and the story is very different. Its progress between 1924 and 1931 was a straight upwardly inclined line. Then came the slump and the rate of increase fell almost to zero. In the same period the reciprocator turned sharply downwards; the turbine was barely affected. I suggest that the rate of increase of the oil engine will continue in the straight line up to about 20 million tons in 1940. If the turbine continues to account for 10 million tons then the reciprocating steam engine must fall rapidly, for the total world requirement appears to be in the neighbourhood of 60 million tons. The drop in the steam reciprocator curve looks rather alarming, but we must have the courage of our convictions and put it in. This, however, may be said, that if world requirements increase above 60 millions the steam reciprocator seems likely to enjoy the difference.

TRAMPS AND FREIGHTERS.

In a familiar passage in Kipling's "Bread upon the Waters" the Scots engineer McPhee describes the "Grotkau" of Piegan, Piegan and Walsh's Line in '84, as "a Clyde-built iron boat, a flat bottomed, pigeon-breasted, under-engined, bull-nosed bitch of a five thousand ton freighter, that would neither steer, nor steam, nor stop when ye asked her. Whiles she'd attend to her helm, whiles she'd take charge, whiles she'd wait to scratch herself, an' whiles she'd buttock into a dockhead." The "Grotkau" was a big ship of her day, but tramps of twice her size are now not uncommon. Their development is one of the most interesting in the history of the sea and a whole lecture might be devoted to it. Here we must be content with a few leading facts, but I am able to give in Table I figures which Mr. T. W. Crozier, now retired, but for many years manager of the Blyth and Tyne Shipbuilding Company, has been good enough to prepare for me.

We may take a few characteristic figures from Mr. Crozier's table. In 1887, a typical tramp was 285ft. long by 38ft. wide with a displacement of 4840 tons. The working pressure was 160 lb. per square inch, the speed 9¾ knots, and the coal consumption 15·44 tons per day. By 1896 the length had risen to 325ft. and the beam to 47ft. with a displacement of 7075 tons. The speed and the boiler pressure were the same as before and the consumption of coal per day was practically the same—a notable advance for a ship nearly 50 per cent. larger.

In 1911 the displacement had risen to about 10,000 tons, the speed was no greater than before and the coal consumption was 24 tons per day—a rather higher rate per ton of displacement. In 1919 the displacement was about the same, the pressure 180 lb. per square inch, and the coal consumption 33 tons per day, but the speed had risen to about 10 knots.

In 1924 the displacement was 11,500 tons, the speed 10¼ knots, the pressure still the same, and the consumption 25 tons per day. This ship had superheat and forced draught. In 1928 the displacement was 12,380 tons, the length 420ft., the speed 10¼ knots, and the coal consumption 33 tons per day.

Between 1887 and 1928 the deadweight carrying capacity rose from about 3000 tons to 9000, and since then tramps or freighters up to 11,000 tons deadweight capacity have been built. The cost per ton of deadweight was in 1928 only a little less than in 1901, or about £8 10s., but in the rosy days of 1921 builders got over £23 per ton deadweight.

The economy of tramps has advanced steadily. Thus if we take coal consumption per knot per ton deadweight carrying capacity we find that it fell in the ratio of 3 to 5 between 1887 and 1928—that is, by 40 per cent.

Mr. Summers Hunter, M.I. Mech. E., has prepared Table II, showing the progress of merchant steamers engined by the North-Eastern Marine Engineering Company. In it pressures up to 220 lb. per square inch for quadruple-expansion engines are listed.

I have endeavoured to analyse these figures diagrammatically and put the curves before you in Fig. 5 for what they are worth. The object was to find out if possible the horse-power per ton, with allowance for speed. The ordinates of the three curves are indicated horse-power per knot (speed) per ton (displacement). In other words, speed ×displacement÷indicated horse-power. In order to secure a reasonable basis of comparison the figures are divided into two groups, one for speeds between 9·3 and 10·5; the other for speeds between 11·5 and 14 knots. The curves begin in 1885 and end with 1934, the four war years being neglected. The lines show an upward inclination which seems to indicate that the efficiency of steamers of this class—the largest is under 17,000 tons displacement—is increasing. If the curves mean anything, and I think they do, we may look in the not distant future for tramp steamers which will show higher knot-tons per horse-power than those of to-day.

CONCLUSION.

In the time available it has not been possible to do more than indicate in the merest outline the progress and probable future of marine engineering. Every class of ship would bear separate investigation, and perhaps some day the Council will invite specialists to deal with their own types.

The ships of which we hear most are like the gentlemen who decorate the top table at public banquets—all "named varieties." But it is the lesser vessels which do the come-day go-day work of the world; the tramps and freighters slogging their patient way across the Bay, facing typhoons in the

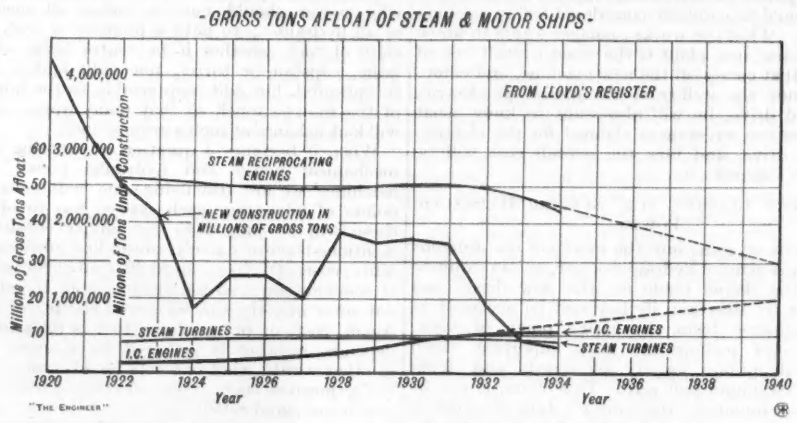


FIG. 4—TONNAGE OF SHIPS WITH DIFFERENT TYPES OF ENGINES

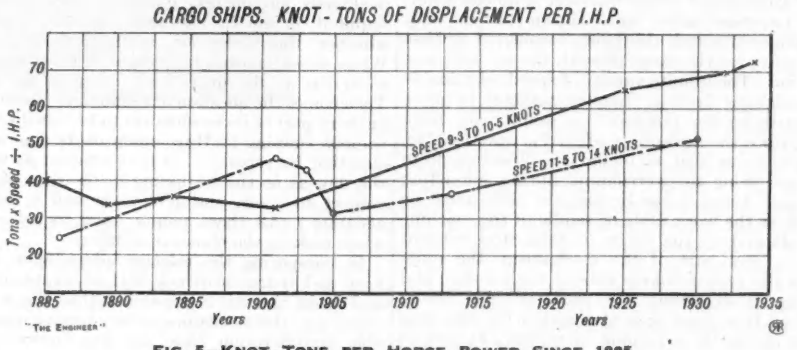

CARGO SHIPS. KNOT - TONS OF DISPLACEMENT PER I.H.P.
Tons x Speed ÷ I.H.P.
SPEED 9·3 TO 10·5 KNOTS
SPEED 11·5 TO 14 KNOTS
1885 1890 1895 1900 1905 1910 1915 1920 1925 1930 1935
Years
Years
"THE ENGINEER"

FIG. 5—KNOT-TONS PER HORSE-POWER SINCE 1885

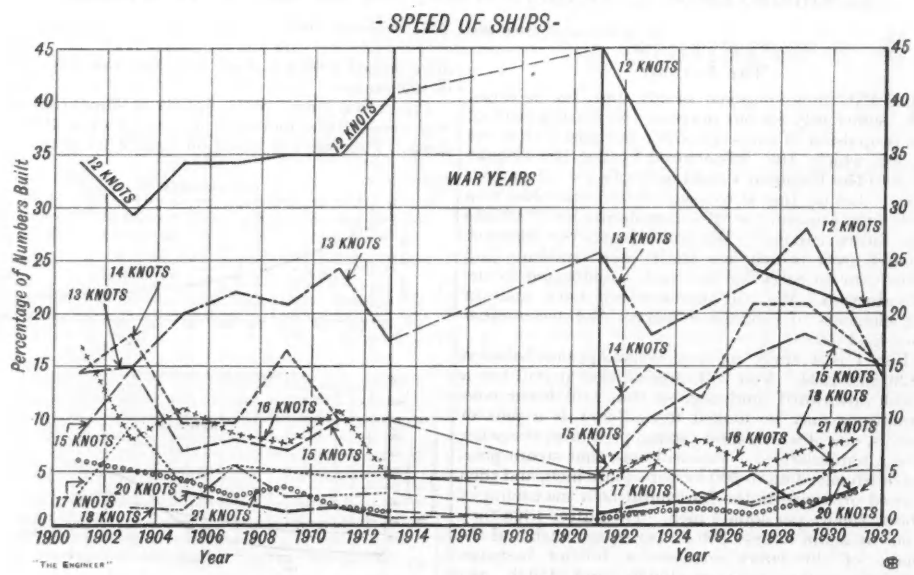


FIG. 3—PERCENTAGE OF SHIPS WITH DIFFERENT SPEEDS BUILT 1900-1932

A SURVEY OF SHIPS AND ENGINES

TABLE I.—*Particulars of Tramp Steamers.*

Type.	Year built.	Particulars of ship. Length, ft. in.	Breadth, ft. in.	Moulded depth, ft. in.	Poop, ft. in.	Bridge, ft. in.	Fo'c'sle. ft. in.	Dead-weight, tons.	Draught, ft. in.	Displacement coefficient	Displacement, tons.	Capacity. Hold, cub. ft.	Gross tonnage.	Net tonnage.	Diameters of cylinders, inches.	Stroke, inches.	Indicated horse-power.	Boilers. Number.	Dimensions. ft. in. ft. in.	Working pressure, lb. per sq. inch.	Service speed, knots.	Coal consumption per day, tons.	Cost, £ per ton dead-weight.
Three-deck rule	1887	285 0	38 0	25 3	29 0	62 0	31 0	3,090	22 0¾	0·737	4,840	144,014	2,198	1,434	22½, 37, and 61	42	—	2	—	160	9¾	15·44	—
Span deck	1891	300 0	40 0	28 1	22 0	66 8	33 0	3,970	21 11½	0·763	5,750	181,451	2,675	1,710	22, 37, and 61	42	—	2§	14 0 × 10 6	160	9½	16	—
Single deck	1896	325 0	47 0	24 10	—	—	—	4,955	20 5	0·800	7,075	234,872	3,139	2,012	24, 40, and 65	42	—	—	—	160	9½	15½	—
,,	1901	308 6	45 8	22 8	15 0	70 0	32 0	4,050	19 2	0·787	6,075	205,364	2,586	1,641	20, 33, and 54	36	—	3	13 6 × 10 3	160	8½	16	8·75
,,	1906	331 0	47 3	24 5	29 0	168 0	34 0	5,315	21 4½	0·803	7,695	299,196	3,016	1,941	24, 38, and 64	42	1,500	2§	15 3 × 10 6	180	9¾	24	6·2
,,	1911	352 6	50 10	27 4	30 0	98 7	30 0	6,860	22 8½	0·810	9,375	353,084	3,942	2,487	25, 41, and 68	45	1,900	2§	17 0 × 11 0	180	9 to 9½	22 to 26	4·95
,,	1911	363 0	51 0	28 9	31 0	95 4	31 0	7,455	23 7	0·810	10,170	375,077	4,331	2,757	26, 42, and 70	48	1,500	2§	17 3 × 11 3	180	9	24	5·54
,,	1916	363 0	51 0	28 9	29 7	97 6	36 0	7,400	23 6	0·805	10,025	384,325	4,359	2,724	25, 41, and 68	48	1,450	3	14 6 × 11 0	180	9	24	8·20
,,	1919	363 0	51 0	28 9	29 9	218 10	36 6	7,340	24 8	0·780	10,140	398,000	4,188	2,579	26, 43, and 72	48	2,000	3 f.d.	14 3 × 12 0	180	9¾ to 10	33	12·55
,, (monitor)	1919	363 0	50 0*	28 9	29 9	218 10	36 6	7,400	24 8	0·780	10,160	406,478	4,088	2,513	26, 43, and 72	48	2,180	3 f.d.	14 4½ × 11 9	180	10	25½	23·30
Shelter deck (monitor)	1924	390 0	52 0†	28 0‡	—	—	—	8,500	24 11	0·779	11,500	509,045	4,507	2,766	26, 43, and 72	48	2,180	3 f.d.	13 10½ × 11 9	180‖	10½	25	9·71
Single deck	1927	405 0	53 6	29 5½	29 8	228 7	40 9	8,660	24 9	0·772	11,790	483,201	4,871	3,024	26, 43, and 71	48	2,150	3 f.d.	16 0 × 11 0	180	10½	33	8·44
,,	1928	420 0	54 0	29 9	23 6	238 0	41 0	9,060	24 11	0·768	12,380	508,791	5.127	3,181	26½, 44, and 73	48	2,200	3	16 0 × 11 6	180	10¼	33	8·15

* Breadth, 50ft. 2½in. over corrugations.. † Breadth 55ft. 4½in. over corrugations. ‡ 37ft. with shelter deck. § Additional donkey boiler provided. ‖ Fitted with superheater. f.d., forced draught.

From 1928 to 1931 vessels of 8,000 to 11,000 tons deadweight were being built as tramps, but recent demands appear to be for a smaller size ; the cost per ton deadweight has not materially changed.

TABLE II.—*Particulars of Cargo Vessels and Machinery.*

Ship.	Year.	Builders.	Particulars of ship. Length, ft. in.	Breadth, ft. in.	Draught, ft. in.	Displacement, tons.	Block coefficient.	Diameters of cylinders, inches.	Stroke, inches.	Indicated horse-power.	R.p.m.	Boilers. Number.	Dimensions, ft. in. ft. in. ft. in.	Working pressure, lb. per sq. in.	Speed, knots.
"Vincedor"	1867	Richardson, Duck and Co.	—	—	—	—	—	42	30	60	—	1	11 6 × 9 0 × 10 0	30	—
"Pelaw"	1868	J. Laing	—	—	—	—	—	(2) 38	30	90	—	1	14 0 × 13 0 × 10 0	30	—
"Ivanhoe"	1868	Pile and Co.	—	—	—	—	—	(2) 38	30	90	—	1	13 0 × 12 6 × 10 6	30	—
"Lampton"	1868	C. Mitchell and Co.	—	—	—	—	—	24 and 48	30	—	—	1	15 3 × 12 11 × 10 2	30	—
"Tweed"	1870	J. Laing	246 0	30 3½	24 3†	—	—	(2) 41	33	110	—	1	11 9 × 10 0	45	—
"Timsah"	1870	C. Mitchell and Co.	252 3½	32 5	17 11†	—	—	31 and 58	33	120	—	2	13 6 × 10 0 × 9 6	65	—
"Success"	1871	Wigham, Richardson and Co.	—	—	—	—	—	38 and 70	36	200	—	2	11 0 × 16 0	65	—
"Zurbaran"	1873	Randolph Elder and Co.	191 11	28 3½	16 11	—	—	25 and 48	30	90	—	1	10 3 × 13 0	80	—
"Genoa"	1875	C. Mitchell and Co.	—	—	—	—	—	33 and 62	45	200	—	2	11 0 × 17 2½	75	—
"Derwent"	1879	R. Thompson and Sons	329 1	36 0	26 10†	—	—	42 and 73	48	250	—	2	13 5 × 17 4	80	—
"Energia"	1883	Tyne Iron Shipbuilding Company	337 0	41 2½	29 1†	—	—	40 and 74	54	300	—	2	13 9 × 18 11½	90	—
"Newcastle"	1885	Swan and Hunter	245 0	34 0	16 9½	2,958	0·74	18½, 30, and 50	36	650	65	2	11 0 × 10 1	160	9·6
"Aire"	1886	W. Dobson and Co.	213 0	28 7	13 0	1 384	0·613	27 and 54	33	700	85	1	16 0 × 11 3	100	12·25
"Ben More"	1888	,, ,,	255 0	34 8	17 11½	3,235	0·71	20, 33, and 55	36	920	79	2	12 6 × 10 6	150	9·77
"Strathmore"	1894	Tyne Iron Shipbuilding Company	350 0	43 0	23 4½	7,970	0·795	24, 40, and 66	45	1,550	70	2	14 10 3/8 × 11 7 1/2	170	9·75
"Homer"	1894	Sir Raylton Dixon and Co.	310 0	42 0	20 0	5,800	0·78	24, 40, and 64	42	1,550	73	2	12 6 × 16 1½	180	9·3
"Kassa"	1901	W. Dobson and Co.	250 0	35 6	18 5½	3,560	0·762	18½, 32, and 54	36	1,100	75	2	13 2⅜ × 11 6	200	10·0
"Colonian"	1901	R. and W. Hawthorn, Leslie and Co.	450 0	54 0	27 8	14,120	0·73	27, 45½, and 76	60	3,400	66	2	16 0 × 16 6	200	11·75
"Ambrose"	1903	Sir Raylton Dixon and Co.	375 0	47 6	22 10½	7,466	0·637	31, 51, and 83	54	4,400	78	4	16 6 × 11 7½	180	14·0
"Ayrshire"	1903	R. and W. Hawthorn, Leslie and Co.	460 0	59 0	27 8	16,600	0·772	(2) 25, 42, and 71	48	5,400	77	4	15 6 × 11 6 f.d.	200	13·5
												1	14 6 × 11 6 n.d.		
"Lusitania"	1905	Sir Raylton Dixon and Co.	420 0	51 0	23 10	10,220	0·7	(2) 23½, 39, and 64	45	4,000	81	4	15 9 × 11 6	180	12·5
"Anglo-Bolivian"	1906	Short Brothers	418 0	54 4	26 9½	13,500	0·775	24½, 35, 51, and 74	51	2,750	67	3	14 9 × 11 8	220	11·2
"Storstad"	1910	Sir W. G. Armstrong, Whitworth and Co.	440 0	58 0	24 10	14,550	0·804	28½, 47, and 78	54	3,650	72·5	3	15 6 × 12 0	180	11·5
"Lycaon"	1913	R. and W. Hawthorn, Leslie and Co.	452 0	56 3½	27 8	14,630	0·73	31, 51½, and 86	60	4,800	80	2	17 1½ × 21 0	195	13·0
												1	13 4 × 10 0		
"San Isidoro"	1913	Sir W. G. Armstrong, Whitworth and Co.	530 0	66 7	27 5	21,680	0·789	28½, 41, 58, and 84	54	4,000	66	4	16 3 × 12 1	220	11·25
"British Prince"	1914	Short Brothers	425 0	56 0	26 6	13,780	0·76	25½, 36½, 52½, and 76	54	3,000	67	3	16 0 × 12 3	220	11·2
"Kingswood"	1925	Northumberland Shipbuilding Company	404 6	53 10	24 9	11,720	0·76	24½, 40½, and 68	45	1,800	61	2 m.	16 6 × 11 6	200	10·0
												1 a.	12 0 × 10 6		
"Burnhope"	1929	,, ,, ,,	369 6	51 8½	21 9	9,180	0·77	20, 28, 40, and 58	42	1,450	57·5	2 m.	15 9 × 11 6	225	9·5
												1 a.	10 0 × 9 6		
"Pendope"	1930	Van der Giessen and Zonen	385 0	56 1	21 1½	9,896	0·765	25, 42, and 73	48	2,800	70·2	3	14 6 × 12 0	225	12·0
"Harpalian"	1932	R. and W. Hawthorn, Leslie and Co.	425 0	56 2½	24 6	12,510	0·752	23½, 40, and 68	48	1,570	52·5	2 m.	15 6 × 11 6	220	10·0
												1 a.	13 6 × 11 6		
"Arctees"*	1934	Furness Shipbuilding Company	360 0	57 3	23 3½	9,625	0·701	21½, 37, and 62	24	1,356	62·0	2 m.	13 6 × 11 6	220	10·5
												1 a.	12 0 × 10 6		

* Isherwood "Arcform." † Moulded depth. f.d., forced draught. n.d., natural draught. m., main. a., auxiliary.

HIGH-SPEED RAILWAY RUNS

King's Cross and Leeds. Vehicles, 4. Axles, 16. Tons, 145.

Miles from King's Cross.	Station.	Time. Booked. h. m.	Time. Actual. h. m. s.	Speed, m.p.h. Passing.	Speed, m.p.h. Average between booking points.	Speed, m.p.h. Maximum attained between booking points.
—	King's Cross	9 8	9 7 45	—		
2·3	FinsburyPark		9 11 45	55·5		
3·2	Harringay		9 12 40	61·0		
3·9	Hornsey		9 13 17	67·0		
4·7	Wood Green		9 14 4	70·0		
6·3	New Southgate		9 15 22	66·0	61·8	84·0
8·2	Oakleigh Park		9 17 7	66·5		
9·0	New Barnet		9 17 50	69·5		
10·4	Hadley Wood		9 19 5	68·5		
12·6	Potters Bar		9 21 0	70·0		
14·3	Brookmans Park		9 22 23	78·2		
17·5	Hatfield	9 27	9 24 45	81·5		
20·2	Welwyn Garden City		9 26 50	64·5		
21·8	Welwyn		9 28 28	65·0	75·2	92·0
24·9	Knebworth		9 31 7	75·0		
28·4	Stevenage		9 33 47	81·5		
31·7	Hitchin	9 38	9 36 5	91·5		
35·6	Three Counties		9 38 30	92·5		
36·9	Arlesey		9 39 25	91·5		
41·0	Biggleswade		9 42 10	92·0		
44·0	Sandy		9 44 6	89·5	89·3	95·0
47·4	Tempsford		9 46 20	90·5		
51·6	St. Neots		9 49 12	85·0		
55·8	Offord		9 52 5	83·0		
58·7	Huntingdon North	9 58	9 54 14	83·0		
63·4	Abbots Ripton		9 57 55	77·8		
69·2	Holme		10 2 12	80·5	74·8	83·0
72·5	Yaxley		10 4 40	74·5		
76·3	Peterborough North	10 14	10 8 20	21·0		
84·7	Tallington		10 16 10	82·5		
88·5	Essendine		10 18 50	83·0		
92·1	Little Bytham		10 21 30	81·5	75·8	86·0
97·0	Corby		10 25 5	85·0		
101·9	Great Ponton		10 28 40	85·0		
105·4	Grantham	10 40	10 31 20	61·5		
109·6	Barkston		10 34 58	75·0		
111·5	Hougham		10 36 25	77·0	79·4	90·0
115·3	Claypole		10 39 7	87·0		
120·0	Newark	10 51	10 42 22	86·8		
126·3	Carlton		10 46 55	82·0		
127·3	Crow Park		10 47 37	80·5	79·2	86·5
131·2	Dukeries Junction		10 50 40	73·0		
131·8	Tuxford		10 51 12	72·5		
138·6	Retford	11 7	10 56 27	67·6		
141·7	Sutton		10 59 0	79·6		
143·9	Ranskill		11 0 36	85·5	76·1	88·0
145·7	Scrooby		11 1 54	86·5		
147·6	Bawtry		11 3 13	82·0		
151·2	Rossington		11 5 50	85·0		
156·0	Doncaster	11 21	11 10 10	41·5		
159·9	Carcroft and Ardwick		11 14 20	68·5		
162·4	Hampole		11 16 20	76·5		
164·6	South Elmsall		11 18 0	81·5		
167·7	Hemsworth		11 20 27	78·0	69·5	84·0
170·3	Nostell		11 22 20	81·0		
171·8	Hare Park and Crofton		11 23 26	81·0		
174·1	Sandal		11 25 10	73·0		
175·7	Wakefield Westgate	11 39	11 27 11	42·5		
178·2	Lofthouse		11 30 4	41·5	49·6	54·0
180·0	Ardsley	11 45	11 32 23	53·5		
183·2	Beeston		11 35 30	62·0		
185·1	Holbeck		11 37 55	20·5	46·8	62·0
185·7	Leeds Central	11 53	11 39 40	—		

All speeds are taken from the dynamometer car records.

King's Cross-Leeds. Vehicles, 4. Load, 145 Tons.

	Booked time. h. m.	Actual passing time. h. m. s.	Distance, miles.	Time on section. m. s.	Average speed, m.p.h.
King's Cross .. .. Dep.	9 8	9 7 45			
			12·6	13 15	57·1
Potters Bar .. .. ..Pass		9 21 0			
			4·9	3 45	78·4
Hatfield .. .. ,,	9 27	9 24 45			
			14·2	11 20	75·2
Hitchin .. .. ,,	9 38	9 36 5			
			27·0	18 9	89·3
Huntingdon .. .. .. ,,	9 58	9 54 14			
			17·6	14 6	74·8
Peterborough .. .. .. ,,	10 14	10 8 20			
			29·1	23 0	75·8
Grantham .. .. .. ,,	10 40	10 31 20			
			14·6	11 2	79·4
Newark .. .. ,,	10 51	10 42 22			
			18·6	14 5	79·2
Retford .. .. ,,	11 7	10 56 27			
			17·4	13 43	76·1
Doncaster .. .. .. ,,	11 21	11 10 10			
			19·7	17 1	69·5
Wakefield .. .. .. ,,	11 39	11 27 11			
			10·0	12 29	48·0
Leeds .. ..Arr.	11 53	11 39 40			
King's Cross-Leeds	2 45	2 31 55	185·7	151 55	73·4
			Average booked speed		67·5

Leeds and King's Cross.—Vehicles, 6. Axles, 24. Tons, 205.

Miles from Leeds.	Station.	Times. Booked. h. m.	Times. Actual. h. m. s.	Speed, m.p.h. Passing.	Speed, m.p.h. Average between booking points.	Speed, m.p.h. Maximum attained between booking points.
—	Leeds Central	2 0	2 0 8	—		
0·5	Bolbeck		2 1 45	28·5	44·1	56·2
2·5	Beeston		2 4 25	54·0		
5·7	Ardsley	2 9	2 7 54	56·2		
7·5	Lofthouse		2 9 53	47·2	52·4	60·5
10·0	Wakefield Westgate	2 14	2 12 50	40·0		
11·7	Sandal		2 15 0	59·3		
13·9	Hare Park and Crofton		2 17 15	60·5		
15·4	Nostell		2 18 40	65·0		
18·0	Hemsworth		2 20 50	66·0	64·8	82·0
21·2	South Elmsall		2 23 35	79·2		
23·3	Hampole		2 25 12	80·0		
25·7	Carcroft and Ardwick		2 27 10	71·2		
29·7	Doncaster	2 32	2 31 7	40·0		
34·4	Rossington		2 35 25	75·0		
38·0	Bawtry		2 38 14	83·5		
40·0	Scrooby		2 39 30	88·0	76·8	88·0
41·8	Ranskill		2 40 50	85·5		
44·0	Sutton		2 42 24	83·6		
47·1	Retford	2 47	2 44 40	81·6		
53·9	Turford		2 49 50	81·0		
54·5	Dukeries Junction		2 50 20	81·2		
58·4	Crow Park		2 53 9	81·8	80·3	83·0
59·4	Carlton		2 53 50	82·0		
65·7	Newark	3 2	2 58 35	76·4		
70·4	Claypole		3 2 20	76·0		
74·2	Hougham		3 5 20	75·0	73·9	79·5
76·1	Barkston		3 6 50	71·0		
80·3	Grantham	3 14	3 10 26	74·4		
83·8	Great Ponton		3 13 20	68·8		
88·7	Corby		3 17 20	86·8		
93·6	Little Bytham		3 20 33	96·0	80·7	100·0*
97·2	Essendine		3 22 46	95·0		
101·0	Tallington		3 25 20	88·0		
109·4	Peterborough	3 40	3 32 5	29·5		
113·3	Yaxley		3 36 12	73·6		
116·5	Holme		3 38 40	82·0	71·8	84·5
122·3	Abbots Ripton		3 43 5	71·0		
127·0	Huntingdon North	3 56	3 46 47	75·6		
129·9	Offord		3 49 17	71·7		
134·2	St. Neots		3 52 47	71·7		
138·4	Tempsford		3 56 3	79·5		
141·7	Sandy		3 58 42	59·2	70·0	81·8
144·7	Biggleswade		4 2 7	62·3		
148·8	Arlesey		4 5 47	75·2		
150·2	Three Counties		4 6 51	74·2		
154·0	Hitchin	4 17	4 9 56	71·0		
157·5	Stevenage		4 12 45	70·0		
160·9	Knebworth		4 15 40	72·2		
163·9	Welwyn		4 18 8	77·0	75·0	84·5
165·6	Welwyn Garden City		4 19 25	80·0		
168·2	Hatfield	4 28	4 21 18	80·0		
171·4	Brookmans Park		4 23 55	72·3		
173·1	Potters Bar		4 25 25	69·7		
175·5	Hadley Wood		4 27 15	77·5		
176·8	New Barnet		4 28 17	79·2		
177·6	Oakleigh Park		4 28 50	80·7		
179·5	New Southgate		4 30 20	83·8	65·0	83·8
181·0	Wood Green		4 31 24	81·0		
181·9	Hornsey		4 32 5	71·4		
182·5	Harringay		4 32 40	64·3		
183·4	Finsbury Park		4 33 30	60·5		
185·7	King's Cross	4 45	4 37 27	—		

* This speed was attained at the 91st mile post from London, just north of Little Bytham Station. All speeds are taken from the dynamometer car records.

Leeds and King's Cross.—Vehicles, 6. Load, 205 Tons.

	Booked time. h. m.	Actual passing time. h. m. s.	Distance, miles.	Time on section. m. s.	Average speed, m.p.h.
Leeds .. ..Dep.	2 0	2 0 8			
			10·0	12 42	47·3
Wakefield .. .. ..Pass	2 14	2 12 50			
			19·7	18 17	64·8
Doncaster .. .. .. ,,	2 32	2·31 7			
			17·4	13 33	76·8
Retford .. .. ,,	2 47	2 44 40			
			18·6	13 55	80·3
Newark .. .. ,,	3 2	2 58 35			
			14·6	11 51	73·9
Grantham .. .. ,,	3 14	3 10 26			
			29·1	21 39	80·7
Peterborough .. .. .. ,,	3 40	3 32 5			
			17·6	14 42	71·8
Huntingdon N. .. .. ,,	3 56	3 46 47			
			27·0	23 9	70·0
Hitchin .. .. ,,	4 17	4 9 56			
			14·2	11 22	75·6
Hatfield .. .. ,,	4 28	4 21 18			
			4·9	4 7	71·6
Potters Bar .. .. .. ,,	—	4 25 25			
			12·6	12 2	62·8
King's Cross .. .. ..Arr.	4 45	4 37 27			
Leeds-King's Cross	2 45	2 37 19	185·7	157 19	70·8
			Average booked speed		67·5

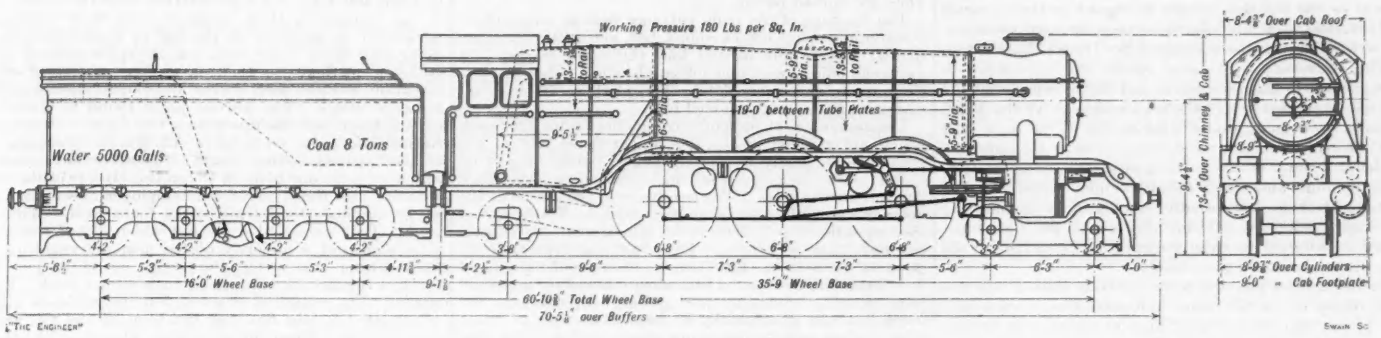
China Sea, picking their courses 'twixt Scylla and Charybdis, nosing themselves into little ports looking for cargoes; never certain where next their lawful occasions may take them. Plain little ships. Here there are no swimming baths, no bridal suites, no lifts, no fancy woods, no priceless fabrics. No artist has built baronial halls in them; no one plays upon their decks. Handmaidens of the world's commerce; loved and cursed like a drunkard's wife. It is with these that this lecture has principally concerned itself. By far the larger number of them are still driven by steam generated by coal, in boilers identical with those our grandfathers used, with engines which differ hardly at all from those built fifty, sixty, seventy years ago.

New engines, new devices, new arrangements arise and the world hears of them. Ships sail with them and undreamt of efficiencies are attained. But you might number these ships, as the saying is, on the fingers of your hands. The tramp is faithful to its past. Over eighty years ago, Scott Russell asked the Society of Arts: "Were they not struck with the fact that nearly all the inventions they now heard of no more seemed monstrously ingenious, whilst the inventions actually in use were those which appeared to have got rid of all the ingenuity and to have merely retained one or two plain, simple, common sense elements in them?"

That is the rock bottom below which invention cannot go. We have seen how the "monstrously ingenious" devices of the early paddle and screw engines gradually gave place to a single type—vertical, inverted, direct acting. That design is as permanent and fundamental as the wheel or the crank. We may be impelled by the constant search for efficiency, to embroider upon it, but if the improvements are too complex they will live their little glorious day and be heard of no more. Their hope of salvation is that they, too, may shed their ingenuity, for sooner or later those that go down to the sea in little ships will return to the "simple, common sense elements."

I would not have you think that I end with a pessimistic note on invention. Far, very far, from it. But I would have you see in the short history that I have unfolded the gradual simplification of the complex and the survival of the, laboriously attained, simplest solution. Further economy in cargo ships must be and will be sought. May it not best be found by extension of the known and approved, by higher propeller speeds, higher pressures, higher temperatures, higher piston speeds, better materials making for lighter structures, better under-water form? These will carry the steam engine forward until, its work well done, it surrenders its place to the internal combustion engine, or to some other prime mover which still lies in the womb of time.

L. N. E. R. PACIFIC LOCOMOTIVE OF 1923



Grate length (on slope) .. .. 5ft. 10 $\frac{15}{16}$ in.
Grate width .. .. 6ft. 11 $\frac{3}{4}$ in.
Grate area .. .. 41·25 square feet

Fire-box—
Height of crown above foundation ring (front) .. .. 6ft. 8 $\frac{13}{16}$ in.
Height of crown above foundation ring (back) .. .. 6ft. 0 $\frac{5}{16}$ in.
Interior length at top .. .. 7ft. 11 $\frac{1}{2}$ in.
Interior length at bottom .. .. .. 5ft. 10 $\frac{11}{16}$ in.
Interior width at bottom .. .. .. 6ft. 11 $\frac{1}{4}$ in.
Interior width at boiler centre line at tube plate .. .. 5ft. 4 $\frac{1}{2}$ in.

Fire-box, thickness of copper plates—
Sides .. .. $\frac{5}{16}$ in.
Back plate .. .. $\frac{5}{16}$ in.
Tube plate .. .. 1in. and $\frac{5}{16}$ in.

Tubes—
Small, number 168
Small, diameter outside .. .. .. 2 $\frac{1}{4}$ in.
Small, thickness .. .. 10 W.G.
Flue (superheater), number 32
Diameter .. .. 5 $\frac{1}{2}$ in.
Thickness .. .. $\frac{5}{16}$ in.
Length between tube plates .. .. 19ft.

Heating surface—
Fire-box .. .. 215 square feet
Tubes, 2 $\frac{1}{4}$ in. diameter .. .. .. 1880 square feet
Tubes, 5 $\frac{1}{2}$ in. diameter .. .. .. 835 square feet
Total .. .. 2930 square feet

Superheater—
Number of elements 32
Outside diameter .. .. 1 $\frac{1}{4}$ in.
Heating surface .. .. 525 square feet
Equivalent heating surface .. .. 787·5 square feet

Boiler—
Outside length of fire-box overall .. 9ft. 5 $\frac{1}{4}$ in.
Outside length of fire-box at bottom .. 6ft. 8in.
Outside width of fire-box at bottom .. 7ft. 9in.
Outside diameter of first barrel (at fire-box) .. .. 6ft. 5in.

Boiler (*continued*)—
Outside diameter of second barrel (parallel) .. .. 5ft. 9in.
Length of barrel .. .. 19ft.
Thickness of plates, first barrel .. .. $\frac{15}{16}$ in.
Thickness of plates, second barrel .. $\frac{7}{16}$ in.
Outside length of smoke-box .. .. 5ft. 11in.
Outside diameter of smoke-box .. .. 6ft.
Diameter of "Ross" pop safety valves 4in.
Number of "Ross" pop safety valves Two
Working pressure .. .. 180 lb.

Frame—
Distance apart .. .. 4ft. 1 $\frac{1}{2}$ in.
Thickness .. .. 1 $\frac{1}{8}$ in.

Axles, diameter of wheels at tread—
Bogie .. .. 3ft. 2in.
Coupled .. .. 6ft. 8in.
Trailing .. .. 3ft. 8in.
Distance between tires .. .. 4ft. 5 $\frac{1}{2}$ in.
Trailing wheel has a radial sliding movement each way of 2 $\frac{1}{2}$ in.

Journals—	Dia.	Length.
Bogie wheel	6 $\frac{1}{2}$ in. ×	9in.
Coupled wheels	9 $\frac{1}{2}$ in. ×	11in.
Trailing wheels	6in. ×	11in.

Crank pins—
Outside .. .. 5 $\frac{1}{2}$ in. × 5 $\frac{1}{2}$ in.
Inside .. .. 8 $\frac{1}{2}$ in. × 5 $\frac{1}{2}$ in.

Coupling pins—
Leading .. .. 4 $\frac{1}{2}$ in. × 4 $\frac{1}{2}$ in.
Driving .. .. 6in. × 4 $\frac{1}{2}$ in.
Trailing .. .. 4in. × 4 $\frac{1}{2}$ in.

Springs—
Bogie = Helical, 10 $\frac{1}{2}$ in. long (free), 5 $\frac{1}{16}$ in. outside diameter, Timmis's section
Leading and trailing coupled = Laminated, 3ft. 6in. centres, 11 plates, $\frac{1}{2}$ in. thick × 5in. wide
Driving = Helical, 11 $\frac{1}{4}$ in. long (free), 6 $\frac{1}{2}$ in. outside diameter, Timmis's section
Trailing = Laminated, 4ft. 6in. centres, 10 plates, $\frac{1}{2}$ in. thick × 5in. wide.

Cylinders—
Diameter .. .. 1ft. 8in.
Stroke .. .. 2ft. 2in.
Number .. .. Three
Centre to centre of outside cylinders .. 6ft. 8 $\frac{1}{4}$ in.
Centre to centre of outside valves .. 7ft. 1 $\frac{1}{2}$ in.

Motion—
Outside valves .. .. Walschaerts
Inside valves .. .. Gresley
Type of valves .. .. Piston
Diameter of valves .. .. 8in.
Return crank radius .. .. 6 $\frac{3}{8}$ in.
Maximum travel of valves .. .. .. 4 $\frac{5}{8}$ in.
Outside lap .. .. 1 $\frac{1}{4}$ in.
Inside lap .. .. $\frac{1}{16}$ in.
Cut-off in full gear .. .. 65 per cent.

Ratios—
Total heating surface .. .. 3455 square feet
Total equivalent heating surface .. 3717·5 square feet
Tractive effort at 85 per cent. boiler pressure .. .. 29,835 lb.
Tractive effort ÷ total heating surface 8·635
Tractive effort ÷ total equivalent heating surface .. .. 8·025
$\frac{\text{Tractive effort} \times \text{driving wheel diameter (inches)}}{\text{Equivalent heating surface}} = 642$

Weights.

Engine—	Tons	cwt.
Bogie	17	1
First drivers	20	0
Second drivers	20	0
Third drivers	20	0
Trailing wheels	15	8
Total in working order	92	9
Tender—		
First axle	13	4
Second axle	14	19
Third axle	14	14
Fourth axle	13	9
Total	56	6
Total engine and tender	148	14

The total length over buffers is 70ft. 5in.

High-Speed Railway Runs.

ON Friday, November 30th, the London and North-Eastern Railway ran experimental trains between London and Leeds at speeds which challenged those attained by the "Flying Hamburger." The engine used for the trip was one of Mr. Gresley's early three-cylinder "Pacifics," built for the Great Northern and completed in 1923. We revive from our pages a weight diagram of the class and a list of the particulars. The trains were light, and on both the down and up journeys a dynamometer car followed the tender. Full records were made, and through the courtesy of Mr. Gresley we reproduce part of one chart showing the train attaining momentarily a speed of 100 m.p.h. The interesting fact is, however, not the maximum speed, but the high average speed maintained for 186 miles, namely, 73·4 m.p.h.

For the benefit of those who like full timing details, we give, on the opposite page, copies of the station-by-station records taken from the dynamometer charts, but the shorter, summarised tables give all the essential particulars.

In a leading article to-day we discuss briefly the probable influence of these remarkable runs on railway operation.

DYNAMOMETER CAR SPEED RECORD BETWEEN PETERBOROUGH AND GRANTHAM

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

GEARED-UP STEAM LOCOMOTIVES FOR HIGH SPEEDS.

SIR,—The astonishing performance of a Gresley "Pacific" when put to a speed test over a long distance, as evidenced by the trial made last week on the London–Leeds route, not only shows what the steam locomotive can do, but also suggests what it might do for fast rail car service if provided with gearing of the increasing order, say, in the ratio of 1 to 1½, and which could be engaged, for example, when 60 m.p.h. had been attained under normal conditions.

Experts, I believe, hold that back pressure is the final limiting factor to the speed of any standard type of steam locomotive, but if crank shaft revolutions were reduced by 30 per cent. for any given train speed, this difficulty would vanish and train speed would depend upon the maintenance of a high torque factor at moderate revolutions in which the reciprocating steam engine of simple type excels. In 1910 a Stanley steam car with a simple H.P. steam engine geared directly to the differential and suspended in an almost identical manner to the engines of the latest "Sentinel" geared freight locomotives, put up a speed of 120 m.p.h. at Daytona Beach, breaking all records at that date. It would therefore seem very probable that a two-geared rail car employing a high boiler pressure and superheated steam, with a moderate number of revolutions of the engine, and geared transmission for the higher speeds, might well put up surprising results on a good road.

Are not the indications explicit that we have not yet got the best out of the old reciprocating steam engine, and shall not do so until we give it the benefit of transmission gear suited to its characteristics? It has, in fact, proved so wonderfully flexible that we have neglected its super-possibilities, or so it would seem after the London and North-Eastern Railway experiment, and the remarkable results with the type of locomotive employed.

S. P. CHRISTIE.

December 5th.

UNIVERSITY DEGREES IN ENGINEERING.

SIR,—In regard to your series of articles upon "University Degrees in Engineering," there appears to be some lack of understanding of the conditions under which evening students take B.Sc. (Eng.). The London Polytechnics, with very few exceptions, are recognised University

Institutions, and the majority of their evening students take the degree as internal and not external students. The evening students are compelled to abide by the same regulations as the full-time people in regard to their courses and practical work and take the same written examination. As is well known, the internal B.Sc. (Eng.) examination of the University of London entails the submission of course work to the examiners, and the evening students are not exempted from this requirement. At the Polytechnics the evening students are taught by the same staff and use the same laboratory apparatus as the full-time students. Many of the evening students obtain second-class honours and there are sometimes "firsts." The evening students are usually employed by engineering firms during the day and thus have a good practical experience in addition to their theoretical knowledge by the time they pass their examinations.

In the articles referred to it has been shown that the M.A. degree of the two oldest universities can be obtained by the payment of a certain sum of money at a definite interval from taking B.A., and that this degree is inferior to the M.Sc. degree of many of the universities, a fact which is not generally realised. When applications are being considered for technical posts, preference is frequently given to people possessing this M.A. degree as against men with good bachelor's degrees, whereas their qualifications are really similar. The M.Sc. degree at some of the universities entails either two to three years of research work or a written examination, whilst it can be obtained more easily at other universities. In view of the general ignorance of the comparability of the standard of the various degrees, it would appear desirable for the universities to introduce a measure of uniformity.

FIVE ENGINEERING GRADUATES.

London, December 5th.

[Our correspondents have satisfied us that the "lack of understanding" to which they refer is not to be found in our recent series of articles. Their object is to counteract the impression that evening students can obtain only the *external* B.Sc. (Eng.) degree of London University. This impression, they fear, may be encouraged by the letters of certain correspondents which we have published previously. It is, of course, wrong and there is nothing in our survey which can be claimed to support it. By following a prescribed course at a recognised "school" or "institution" and passing prescribed examinations a student can obtain the *internal* B.Sc. degree. The University specifies the minimum number of hours which must be spent on the internal degree course, but does not restrict these hours to the daytime. An internal degree may therefore be obtained entirely by evening study. We would like to point out that a converse impression also seems to prevail and that it is equally erroneous. It is sometimes implied that the holding of an external degree necessarily means that it has been obtained by attending evening courses of instruction. Full-time, or day, courses are provided at Nottingham and certain other university colleges and at a number of technical colleges and similar institutions; these courses lead to the London external—*not* the internal—degree. An external degree may therefore be obtained entirely by day study. All these points are to be found embodied in our survey. Our correspondents' letter would appear to require some qualification with respect to the number of London polytechnics which are "recognised institutions" of the University. Under the new regulations which will come into force in 1936 the number of such "institutions" which a student may attend for the purpose of qualifying for the *internal* degree will be reduced to four.—ED. THE E.]

LONDON AND BIRMINGHAM RAILWAY.

SIR,—Are any of your readers able to supply me with a list of the locomotives built by Messrs. Maudslay for the London and Birmingham Railway?

SEARCHER.

December 10th.

The Garage in Venice.

WE published in our issue of December 29th, 1933, a description of the Mestre-Venice Viaduct, in which mention was made of the Venice garage, then in course of construction. This garage was completed a few months ago and represents by its size and general planning a noteworthy building which becomes all the more interesting when the general topographical conditions of Venice are remembered, where up to a few months ago only waterborne traffic was possible. It is precisely this peculiarity of the town, in which no roads for vehicular traffic are available, which created the difficult problem of finding first the required space for the garage itself, and secondly, for the approach road.

The garage flanks one side of the new square, Piazza Roma, which has an area of 430,560 square feet. The garage has a frontage to the bridge road of 114·50 m. (375ft. 7⅝in.) and towards the square of 75·50 m. (248ft. 3½in.). The height of the main body of the building is 23 m. (75½ft.) and that of the two tower-like structures within which the ramps are built is 27·50 m. (90ft. 2⅝in.). For the time being only half of the building has been constructed and the ground floor (in respect of the square) of the other half. The second part will be taken in hand in due course. The height of the building was limited to 75½ft. in order not to disturb the characteristic sky line of Venice. The garage contains seven floors in all, and communication between them is effected by means of two helicoidal ramps, one for incoming and the other one for outgoing cars. These ramps have been constructed in the tower-like structures at the extremities of the present building, which correspond to the centre of the side façades after completion of the rear portion. The width of the ramps is 4 m. (13ft.), their average gradient is 1 : 16⅔, with a maximum of 1 : 10, and the length of ramp between two floors is 360 m. (1181ft.). They are asphalt paved.

The frontage of the main entrance floor is occupied by the administrative offices, shops, bar, and motor car sales rooms. Inside the arrival hall there are tourist and exchange offices, post and telegraph office, police station, cloak room, and a day hotel. Two electric lifts and two staircases have been provided for.

The garage has at present accommodation for 1200 cars, which are garaged in the four upper floors and in the ground floor, partly in lock-up boxes, partly in parking spaces. The lock-up boxes are arranged in the upper floors along the sides. The free space in the centre of the floors has a width of 20·50 m. (67ft. 4⅝in.). The height of the upper floors is 3·30 m. (10ft. 9⅞in.); that of the main entrance floor is 3·80 m. (12ft. 5⅝in.) and that of the ground floor 3·85 m. (12ft. 7⅝in.). The area of the ground floor has been increased by extending it below the approach ramp running alongside the building. In this way the width has been increased by 10·50 m. (34ft. 5⅝in.). There is a parking hall for motor omnibuses, motor cycles, and bicycles on the lower ground floor, which is on the level with the square. Further parking space for 400 cars is available on the two terraces. On completion of the rear portion of the building there will be further accommodation for 1000 cars, and the claim to be the biggest garage in Europe will then be justified.

THE SERVICE STATION

The impossibility of erecting private garages in Venice necessitated the concentration of all services on a large scale. The general service and supply station occupies the whole length of the building between the two towers. It is fitted with five hydraulic lifting tables, a lubricating plant, comprising a central compressor and distributor of grease under pressure, a distributing plant for extra heavy oil for differential gears, a brake testing and registration plant, a repair pit, and a washing and cleaning plant.

The mechanical and electrical repair hall is fitted with the most modern appliances and machinery, so that even the most difficult repairs can be executed on the spot. Four pits for motor cars and one for omnibuses have been built, each pit communicating on floor level with an adjoining room which is fitted up as a workshop, &c. A separate body shop is provided with all the necessary machinery for any kind of repairs and paint work.

Each floor has its own compressed air plant for tires, as well as running hot and cold water installations. The whole building is heated by a system of hot air distributed through eleven ducts by means of electrically driven fans. During the summer months the ducts are connected to an air cooling plant. The offices and shops are heated by a central heating installation which supplies hot water to all floors.

The electrical plant comprises a triple illumination set—full light, half, night service—an autonomous emergency illumination plant, an automatic fire alarm installation for the whole building, and an automatic controller for closing and opening all main doors.

The garage has been built to the plans and specifications of Signor Ing. E. Miozzi, Chief Engineer of the Municipality of Venice, which owns the garage. Signor Miozzi is the author of the project of the Venice-Mestre Viaduct. The commercial exploitation of the garage has been taken over by the Azienda Generale Italiana dei Petrolii (A.G.I.P.), the big oil concern, which owns a number of first-class garages in the principal towns of Italy, and to whom we are indebted for permission to reproduce the photographs on this page and page 594.

SIXTY YEARS AGO.

A RECENT case—*Davies v. Richard Johnson and Nephew*—tried by Mr. Justice Luxmore may be compared with a somewhat similar action—known as the "Darlington Notice Case"—which sixty years ago created much excitement in the iron trade of the North of England. In the recent case, it will be recalled, a group of workmen objected to the application of "time-studying" methods to the piece-work operations which they were engaged to perform and asked for a declaration from the Court that it was implied in their contracts that their employers would not do anything to prevent or hinder them from doing their work. They held that the application of time-studying methods to their operations distracted their attention, reduced their output and caused them to suffer a loss of wages. The learned judge found in favour of the employers and dismissed the action. The "Darlington Notice Case" was tried before Mr. Turner, the judge of of the Durham County Court. According to a leading article on it in our issue of December 11th 1874 the case arose as the result of certain employers, owning iron-works, having closed their works for a week—Whitsun week. They exhibited a placard which stated that "in consequence of a majority of the men not requiring to work during that week, the works would be closed." Some of the men objected to losing a week's work. They applied to be employed as usual, but the application was not granted for the fires had not been lit and the works were laid off. When the employers refused to pay them their wages for the idle week the men sought to recover them in the County Court. The judge found in favour of the men, arguing that so long as a workman was held to his contract of hiring, as a hired servant the master was bound to find him work. We agreed with that interpretation of the law. The contract, we said, was two-sided. One part bound the man to work and the other bound the master to employ. We did not, however, fear, as many others feared, that the judgment would have a distressing effect on industry in general. While the law of master and servant clearly supported Mr. Turner's finding, it was well known that, for the convenience and ultimate advantage of both parties, its application to the particular point in question had come to be disregarded. Strictly speaking an employer who changed from full-time to short-time working when trade was bad could be sued by his hired servants for providing them with only partial employment without terminating the full-time agreement. If however the workman chose to exercise that right the employer could equally on his part sue a workman for breaking his contract every time he took a day off for his own pleasure or if he became intoxicated and unable to work. Another difficulty in the law of master and servant had also been allowed to remain in abeyance by common consent and for the common advantage, namely the difficulty of determining in every department in every trade what constituted full-time work, particularly in the case of piece workers. If, we said, the men insisted upon strict law the employers would, no doubt, insist upon it also on their side. We had therefore no fear whatever of the probable outcome of Mr. Turner's judgment in the "Darlington Notice Case." . . . The recent and the old case differ in their details but they are fundamentally alike in this respect, that in each the men brought an action against their employers for doing something which prevented, or was alleged to prevent, them from earning their normal wages.

UNIVERSITY DEGREES IN ENGINEERING.

THE series of articles bearing the above title, of which the sixth and last appeared in our issue of December 7th, is now being reprinted in pamphlet form. The articles give a survey of the regulations and customs governing the granting of the degrees open to engineers at the universities of Great Britain and Ireland. Copies of the pamphlet may be obtained from this office, price 1s. net each.

PRODUCTION has been started at the new brick-making plant at Bishopbriggs, Glasgow. The total capacity of the works is 180,000 bricks weekly.

Railway and Road Matters.

THE London Passenger Transport Board is using some 100 lb. per yard British Standard flat-bottomed rails, 38ft. in length, on the Piccadilly section between Ravenscourt Park and Stamford Brook. They are there for experimental purposes.

PART of the work to be carried out by the French railway companies for the relief of unemployment is the provision of automatic colour light signals on 4500 kiloms.—roughly 2800 miles—of main line. There is also to be the general adoption of green instead of white for "clear" in the running signals and of yellow in place of green for "caution."

THE London and North-Eastern new locomotive "Cock o' the North" has left for France, where it will undergo a series of tests at the new locomotive testing plant at Vitry, near Paris. It has taken its own supply of coal. The transport of this big engine, which weighs 165¼ tons, including 55¼ tons for the tender, has been made possible by the use of the train ferry between Harwich and Zeebrugge.

IN Sir Felix Pole's report on transport in Northern Ireland the recommendation was made that the Clogher Valley Railway should be shut down. The Tyrone County Council has, however, passed unanimously a resolution deprecating that suggestion, as the railway is performing a service which cannot be replaced by motor transport without a great deal of extra expense being involved, which would fall upon the present users of the railway.

THE coroner resumed and concluded on Monday last the inquest into the death of the driver and fireman of the L.N.E.R. train which was derailed at Wormley, near Broxbourne, on November 27th, after collision with a motor lorry at an occupation crossing. The jury returned a verdict of "Accidental Death," with the recommendation that something should be done to prevent a recurrence. As we go to press the Ministry of Transport inquiry by Colonel Trench is also being concluded.

THE Railway Returns for 1933 show that the quantities of coal consumed and of lubricating oil used by steam locomotives and steam rail-motor vehicles in that year were 11,659,015 tons and 30,902,754 pints respectively, compared with 11,683,330 tons and 31,404,537 pints respectively in 1932. The amount of coal consumed per engine-mile by steam locomotives remained at 52·41 lb., and the consumption of lubricating oil was 6·19 pints per 100 engine-miles in 1933, compared with 6·27 pints in 1932.

VERY little work of interest is foreshadowed by the Bills of the railway companies for the new session. The only new railway is one, 3¼ miles long, by the Southern Railway to join the Lydd branch with the New Romney branch. The same company also seeks for authority to vary the works at Leatherhead that were sanctioned in 1930. Part of the Grantham Canal is to be abandoned by the L.N.E.R. The intimation that a copy of the Bill may be inspected and copies obtained at the station-master's office is, it seems to us, new.

THE Lewisham loop—between Nunhead and Lewisham—of the Southern Railway, which was built and opened a few years ago, mainly for the through goods trains between the northern railways and the exchange sidings at Hither Green, is to be equipped for electric traction, and that will allow for the greater use of St. Paul's and Holborn Viaduct stations, to the relief of London Bridge, Cannon-street, and Charing Cross. The line between Woodside and Sanderstead, *viâ* Selsdon-road, is also to be made available for electrically operated trains.

FROM a paper by Mr. F. S. Jackson, recently read at the Institution of Railway Signal Engineers, it appears that the Whitemoore marshalling yard of the L.N.E.R. covers an area of approximately 1½ miles by ½ mile, and consists of 50 miles of single track, providing accommodation for about 11,000 wagons. The total cost, including additional locomotive plant and a new generating station, was in the neighbourhood of £500,000. It has been stated that a saving of £30,000 per annum has been effected by the up yard alone; no figures have yet been issued as to the recently opened down yard.

THE Bill of the London Passenger Transport Board, which will be considered during the present session, proposes to make changes in the tracks at each of the junctions of the Metropolitan section with the District section. At Cromwell Curve the two Metropolitan lines will be made to pass under the east-bound District line from Earls Court, and the Metropolitan tracks will then be in the centre between the eastbound and westbound District lines. The scheme suggests that South Kensington will be rearranged so as to be similar to Edgware-road, where the centre lines can be used as bay lines or as through loops. Aldgate East Station, where the Metropolitan joins the District at the eastern end, is to have a new station with exchange facilities between the two sections.

THE approaching Christmas Eve will see the sixtieth anniversary of the worst railway accident in England; more lost their lives in the Tay Bridge and Quintinshill disasters, but they were in Scotland, whilst that at Armagh was in Ireland. It was on December 24th, 1874, that a broken tire on a passenger coach led to the derailment of a passenger train at Shipton-on-Cherwell, near Oxford, Great Western Railway, and to thirty-four passengers being killed. There had been three days of severe frost, and the jury at each of the two coroner's inquests that were necessary ascribed the cause of the failure of the tire to the effects of the severe weather. The Board of Trade inquiry led to a different conclusion. It was presided over by Colonel Yolland, who had Mr. W. W. Ravenhill (barrister) as assessor, and was held at the Westminster Sessions House. The tire was fastened to the rim of the wheel by four countersunk bolts, a practice which had not only been condemned by the Board of Trade inspecting officers, but had been abandoned in 1861 by the Great Western Company, and then resumed. The consequent report recommended improved fastening of tires, continuous brakes for passenger trains, and a revision of the rules as to what a driver should do if vehicles are off the line.

Notes and Memoranda.

EXTENSIONS to the world's largest low-temperature plant for producing smokeless fuel, petrol, and fuel oil from coal at Askern are shortly to be officially opened. The seventh and eighth batteries of retorts now being completed will constitute an addition to the works of seventy-two retorts, making a total of 288 retorts for the whole plant. The extensions will increase the Askern output by 33⅓ per cent., thus enabling the company better to meet the increasing demand for coalite, fuel oil, and coal petrol.

THREE years ago, according to Mr. A. D. Howell, the Neath gas department commenced experimenting with the application of gas for the various heating processes in a local tin-plate works. As a result, two of the largest tin-plate works in South Wales had completely eliminated the use of coal in their works. The cost showed that gas was more expensive than coal, but the quality of the finished product was very much better and more than compensated for the increased fuel cost. Another big factor was that the manufacturers were able to reduce the labour rate; at the same time this reduction did not affect the wages of the workmen because it increased output.

THE object of a review published in the October issue of the *Bulletin* of the British Cast Iron Research Association is to stress the fact that the rate of corrosion of cast iron, as a material for pipes laid in the ground, is only very slightly in excess of that of materials of far more expensive character. Bearing in mind its cheapness, cast iron pipe has a far better ratio of cost to life than any other ferrous material, and the widespread use of cast iron for pipes is amply justified. As the analyses and structures of the materials used in some tests made in America have not yet been given, it is difficult to say how far the conclusions are applicable to pipes made in Great Britain, but the generally lower total carbon content and higher phosphorus content of British irons suggest that they offer greater resistance to corrosion than American irons.

AN announcement has been made by Imperial Chemical Industries, Ltd., that the company is shortly to put in operation a new process for the manufacture of tetrahydronaphthalene, which is to be marketed under the name of "Tetranap." Better known as "Tetralin," its registered trade name as manufactured in Germany and America, tetrahydronaphthalene is a water-white liquid of great stability, manufactured by the catalytic hydrogenation of pure naphthalene. Its use either in liquid form in scrubbers or in the form of vapour introduced into the actual gas stream, has for some time been well-established practice in Germany and America for the prevention and removal of naphthalene and gummy deposits in gas distribution systems. In both these countries the method is stated to have been developed with considerable success, and to have cut down a notably heavy item in gas distribution costs.

IN a paper on "Enamelling Iron," before the Institute of Vitreous Enamellers, Mr. N. H. Oakley-Evans said that the desirable qualities of a high-grade enamelling iron may be summarised as follows:—Uniformity of structure and analysis; a clean open-grain matt surface that grips and absorbs the coating; well degasified iron that reduces to a minimum the risk of pinholes, blisters, &c.; homogeneity and uniform processing to minimise risk of distortion and warping; weldability and good working qualities. Typical chemical analysis: carbon, 0·025; silicon, trace; manganese, 0·030; sulphur, 0·035; and phosphorus, 0·009 per cent. Approximate physical properties: tensile strength, 20 tons per square inch; yield point, 70 per cent. of tensile; percentage elongation in 8in., 25 per cent.; typical Olsen test on 20 g., 0·375; Rockwell hardness (B scale), 40. These values will vary, depending on the processing of material, which should be adjusted to meet individual requirements, whether for flat work, drawing, forming, or spinning.

IN the course of a paper on the decay of wood before the Society of Chemical Industry, Dr. Rudge said that the major conclusions drawn from investigations led to the formulation of a theory of decay based on ionic infiltration, which claimed that in its insipient stages decay was brought about by the invasion of what had been called the "ligno cellulose complex," by bicarbonates in solution. The complex was rendered unstable to atmospheric conditions and thereupon gave rise to degradation products. Seasoning now assumed a new significance, for modern methods of kiln-drying were, as a rule, hit-and-miss processes, devoid of scientific basis. From the standpoint of the new theory the prevention of fungus attack was not the sole function of a successful preservative. Creosoting was to-day practically the universal method of timber preservative treatment. Observations, however, indicated that the existing meaningless and arbitrary specifications for creosote might profitably be replaced or augmented by one expressing not only the toxic character of the material, but also such physical properties as surface tension and viscosity.

A SYMPOSIUM has been issued by the American Society for Testing Materials on outdoor weathering of metals and metallic coatings. It evaluates much of the performance data obtained from the extensive outdoor weathering tests carried out by the Society's committees on corrosion of iron and steel and on corrosion of non-ferrous metals and alloys. The symposium is intended to illustrate applications of the Society's corrosion test data in solving materials problems, and the five technical papers discuss the following subjects:—Outdoor test results on bare and metal-coated ferrous specimens; the harmony of outdoor weathering tests; influence of rainfall and smoke on the corrosion of iron and steel; early interpretation of test results in the atmospheric corrosion of non-ferrous metals and alloys; galvanic corrosion by contact of dissimilar metals. An interpretation of corrosion test results necessarily introduces various viewpoints. The very considerable portion of the publication devoted to discussion thus gives a broader view of the field. Extensive contributions from technologists in England indicate interesting results of widespread test programmes conducted here and comparisons with conclusions reached in the United States.

Miscellanea.

A SITE has been purchased at Litherland, near Liverpool, and work is to be started immediately on the erection of a new tin smelter there.

IT was recently stated in the House of Commons that the revenue from the duty on heavy oils up to the end of October this year was £4,140,000.

THERE are now nine squadrons of the Royal Air Force flying on petrol produced from Askern coal by the low-temperature carbonisation process.

A NEW plant is shortly to be opened at Sawalji in the Ukraine, for the production of 4000 tons of refined graphite annually from local deposits capable of supplying 100,000 tons of the crude mineral a year.

THE Council of the North-East Coast Institution of Engineers and Shipbuilders has decided to celebrate the Institution's fiftieth anniversary with a series of functions in the form of a summer meeting in June or July next.

THE *Northern Miner* estimates that Canadian gold production this year will reach a total value of 105,000,000 dollars, and that the 1935 total may be as much as 116,000,000 dollars. These figures are based on a survey of existing and planned milling units producing gold for sale at current price levels.

THE United States Federal Government at the present time is engaged in the construction of a group of great projects for power development, flood control, navigation or water conservation, projects that will cost in the neighbourhood of 400,000,000 dollars, and will increase the nation's power-producing capacity by 1,000,000 h.p.

ACCORDING to the Milan correspondent of the *Financial Times*, the Italian State Railways have ordered six high-speed electric trains for passenger traffic. The trains will be capable of an average speed of 88 miles per hour, with a top speed of 100 miles per hour. Each train will comprise six undetachable carriages, forming a self-contained unit.

A REPORT of the Electricity Bureau of the Japanese Department of Communications shows that the total number of electric power plants in Japan at the end of 1932, including public, private, Government-owned and railway power plants, was 7720, of which 7398 were in operation and 322 under construction. The total generating capacity of the stations in operation was 4,933,061 kW. and of those under construction 1,865,379 kW. Those in operation included 3,105,930 kW in water power stations, and 1,827,131 kW in thermal stations.

AN attempt to improve the standard of skilled engineering apprentices is described in the Annual Report of the National Institute of Industrial Psychology. The Institute is co-operating with the Birmingham Education Committee in experimenting with the use of special psychological tests to predict the suitability of boys for training for skilled engineering trades. According to the Report, the results already indicate that the tests give a far more reliable prediction of a boy's subsequent success in skilled engineering work than has hitherto been possible.

AT a recent dinner, Mr. A. Williamson, who is general manager of the Steel, Peech and Tozer branch of the United Steel Companies, Ltd., said that at Templeborough, within the past few weeks, they had broken all previous records in output, in so far that, with ten furnaces running, they had got the output up to 11,000 tons per week: 1100 tons per furnace per week was an achievement, especially when it was taken into consideration that, only a few years ago, it was thought they were going to establish a record with 700 tons per furnace per week.

THE Skoda and Cesko-Moravska concerns, the two largest metallurgical and automobile concerns in Czecho-Slovakia, have concluded a production quota agreement to regulate the production of machinery, locomotives, and electrical plant for a period of fifteen years, says the *Iron and Coal Trades Review*. Price regulation is automatically provided for by this arrangement, which does not, however, apply to motor car building. The agreement is regarded as of outstanding importance to the future development of the Czecho-Slovak machinery industry.

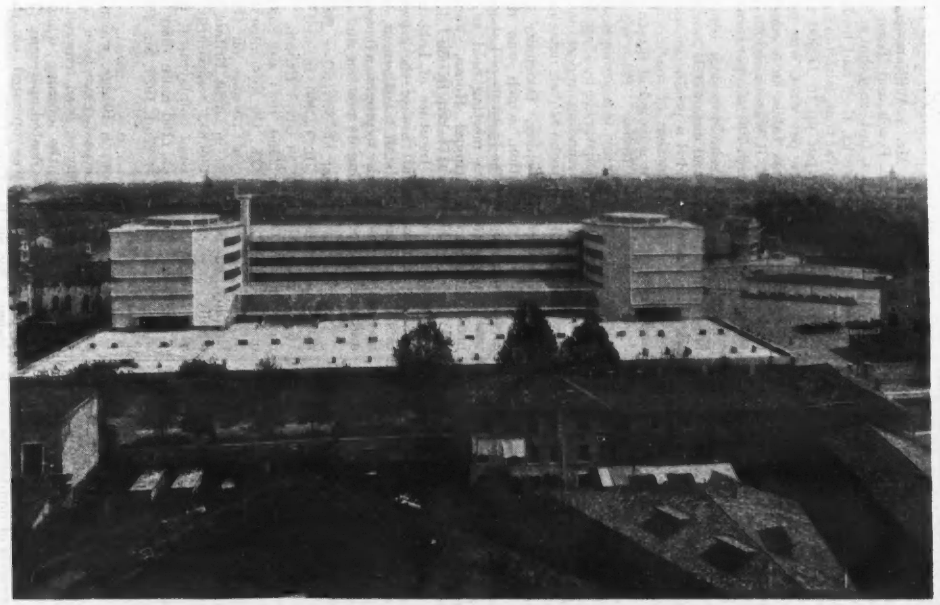
ON Wednesday evening, December 5th, the Staff Management Association, which was recently formed under the auspices of the Institute of Labour Management, was inaugurated by a meeting held at the Institute's headquarters at Terminal House, Victoria, London, S.W.1. The chair was taken by Mr. J. H. Fullwood, the President of the Institute of Labour Management, who explained that, in view of the growing recognition of the importance of staff management, the Association had been formed in order to provide a focus for information and opinions concerning its practice and development.

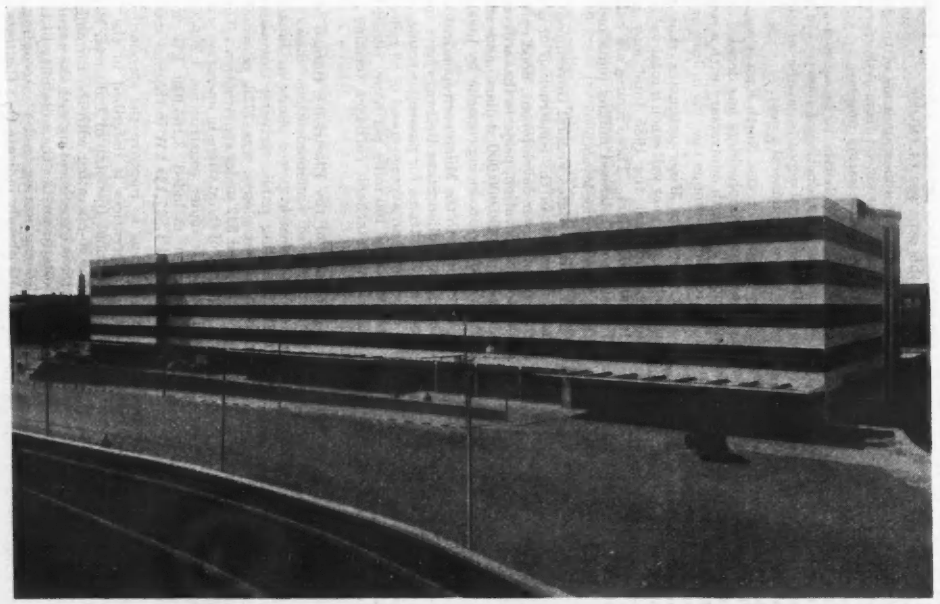
IT is estimated that at November 26th, 1934, there were approximately 10,212,000 insured persons, aged 16–64, in employment in Great Britain. This was 6000 more than on October 22nd, 1934, and 252,000 more than on November 20th, 1933. On November 26th, 1934, the numbers of unemployed persons on the registers of Employment Exchanges in Great Britain were 1,729,838 wholly unemployed, 309,643 temporarily stopped, and 81,304 normally in casual employment, making a total of 2,120,785. This was 1150 more than the number on the registers on October 22nd, 1934, but 159,232 less than a year before.

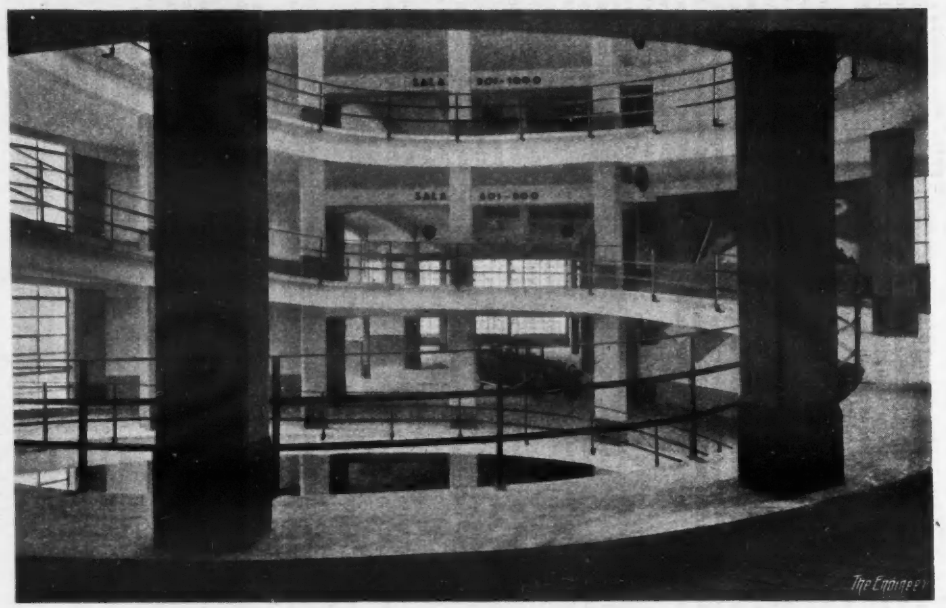
REPAIRS to the Howrah Bridge, which have been in progress for some time past, have been completed, some 400ft. of the bridge having been renewed. Between the two new sections is the opening which enables the removal sections to be floated upstream. The mechanism by which the flap was operated on the old bridge, designed by Sir Bradford Leslie, consisted of balanced tanks into which water was flooded and drained out as required. In the new sections a more modern procedure has been adopted. These heavy flaps, each of which consists of about 800 square feet of roadway and weighs nearly 30 tons, are operated by electric motor and screw gear working in ball bearings. Steel has been substituted throughout for the timber frames upon which the original bridge was supported.

THE NEW GARAGE IN VENICE

(*For description see page 592.*)







ABOVE:—REAR OF GARAGE
BELOW:—THE HELICOIDAL RAMP FROM ABOVE

ABOVE:—MAIN FRONTAGE
BELOW:—PART OF THE HELICOIDAL RAMP

The Engineer

DECEMBER 14, 1934.

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NOTICES TO READERS.

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DEATH.

On Saturday, Dec. 8th, CHARLES EDWARD LACY-HULBERT, Founder and Managing Director of Lacy-Hulbert and Co., Ltd.

THE OLD DOG.

THERE was something lightly dramatic about the special runs on November 30th of a steam locomotive between London and Leeds. It is not that a speed of a hundred miles per hour was touched at one point, or that an average of over 73 m.p.h. was attained, or that the ordinary timing was reduced by over forty minutes. Anyone who respects the steam locomotive knew long before the test was made that it could do all these things if the road and the load were right. No; the dramatic effect was not in the achievement, but in the method employed. Mr. Gresley was out to show that an ordinary steam train of appropriate weight could do a long journey with approximately the same timing as the "Flying Hamburger," and to do it he picked an engine off the shelf, so to speak, and told it to beat the record. It was not by any means a new engine, it was not tuned up with any special care for the occasion; it was not trained, as one might say, for the race. It was just an ordinary engine, one of Mr. Gresley's Great Northern "Pacifics," which first took the road in 1923, has covered some 653,000 miles in its eleven years of existence, and has run over 44,000 miles since its last repair. This old dog was set against the young German greyhound and, to mix metaphors, showed that it could move just as nimbly as the champion lightweight.

The records of the runs and full particulars of the engine will be found on another page. As we have said, they will not surprise steam locomotive men, who have long been aware of the abilities of their engines. But they will surprise and discountenance a public which is inclined to sneer at the old-timers and to undervalue their powers. Their next question will now be, of course—"Well, what are the railways going to do about it? They have shown that long runs can be made at high speeds. Will they now include such runs in their schedules?" The answer, so often made, is that it all depends upon the economics of the railway system. If it pays to run trains of three or four coaches between London and Leeds—186 miles—in 2½ hours, then, no doubt, they will be put on. But it must not be thought that the economics begin and end with the high-speed train itself. All sorts of other trains have to be considered, and the suitability of the road, the wear and tear on it, the cost of upkeep, and so on, are items which must be taken into the account. Whilst it is, indeed, far from improbable that such a service could be given with our present locomotives and coaches, they are not really suited to it—not having been made for it—and it would be better to design a special high-speed type. In this case, even more than in ordinary cases, the train and the road must be considered together. Heavy rolling stock, built to give passengers the greatest comfort, all the amenities that can be crowded into a small width, and sprung in a way that experience has proved best for the speeds it is designed to maintain, may prove much too hard on the rail and the permanent way. The locomotive, too, capable as it is of holding a high speed for long distances without distress, may be too heavy for the duty and too hard on the rail at such speeds. On the whole, then, we must not expect to see this *tour-de-force* converted into regular practice; it would, we suspect, prove too costly when the whole economics of railway passenger transport were considered. It will be interesting to compare the L.N.E.R. train with the "Flying Hamburger." The former weighed on the down journey, engine included, 294 tons; the latter weighs under 80 tons. A passenger train equivalent to the test train might carry 150 passengers; the latter 100. The former probably developed something like 1600 h.p.; the latter requires half that power. The former burns coal; the latter consumes oil. Broadly, the former was not designed for extra high speeds, whereas the latter was designed and built primarily for their attainment.

We have suggested that it is improbable that a frequent 2½-hour service between London and Leeds will be established with normal steam trains as a result of this test. But we understand that the runs have caused some excitement in Germany, and the offer of a prize of £3000 just made by the Ruhr Coal Syndicate for the plans of a coal-driven train of the "Flying Hamburger" type is of considerable interest. It opens up an aspect of the trial which will appeal to our Coal Utilisation Council. We suspect, however, that German engineers are not thinking so much of a steam locomotive fired with coal as of a coal-dust engine suitable for traction. That may come in time, but for the present we must expect to see further developments of locomotives—or, rather, railcars—propelled by the utilisation of liquid fuel in one way or the other. It does not seem at all likely that the brilliant success of Mr. Gresley's experiment will affect in any way the future of such developments. The most that could be expected from it would be the appearance of a few "limited" expresses operated by ordinary locomotives, until such time as the new developments which are taking place entirely satisfy the requirements of the railway companies.

The Highways of London.

ALMOST one hundred years ago, and long before the internal combustion engine had wrought a revolution in the means of transport on roads, a Select Committee of the House of Commons was appointed "to consider the most effectual plan for raising of money to carry into effect the necessary improvements required in the cities of London and Westminster, borough of Southwark, and counties of Middlesex and Surrey." It was by no means the first time that means of reducing congestion in the streets of the city had been considered. It is, in fact, doubtful whether at any time in history the flow of traffic has been as free as is desirable. But it was one of the first endeavours of the nineteenth century to grapple with the evil. Again and again, before the century was out, it was found necessary to appoint a Select Committee or a Royal Commission with a similar purpose. Railways encouraged business men who had theretofore lived in the heart of the city above their shops or offices to move out each night nearer the country into quieter surroundings. London began to spread. With the advent of mechanical transport the condition of the roads became worse. Each morning and evening hundreds of thousands of business men required transport by rail and road from home in the suburbs to office and back again. In spite of much productive work in the early part of the present century by the London Transport branch of the Board of Trade, the problem has grown more acute year by year. Mechanical transport has developed too rapidly and streets have not been able to alter in conformity with its needs. To modify a city an "inertia" must be overcome. Except at enormous expense streets cannot be widened until leaseholds of buildings fall in. Neither bridges nor tunnels can be built without years of consideration and study of the conditions. Railways and railway stations, built at a time when street transport was of a different character, cannot be shifted with impunity. Pedestrian rights, frontagers' rights, loading and unloading rights, the habits of a whole people cannot be modified overnight. But the number of vehicles on the roads, despite legal restrictions and industrial depression, increases yearly; and London's population travels each night further outwards, seeking proximity to the country, or lower rents, as land value rises at the centre.

No purely parochial body like the one hundred and thirty or so authorities which control the destinies of the different parts of London, can possibly have a sufficient breadth of view to be entrusted entirely even with the development of its own particular district. Each authority necessarily views the traffic problem in the light of its own experience. So far as its own finances or those obtainable from the Ministry of Transport will allow, it will carry out work in its own area despite the fact that the modifications effected may make impossibly costly for years to come the development of some far-reaching scheme of much greater influence and importance. The planning of new "arteries" and the disciplining of traffic into "roundabouts" and "one-way" streets cannot be studied parochially. The Aldwych "one-way" system influenced the flow of traffic from Parliament-square to St. Pancras and from St. Paul's to Hyde Park Corner. The partial closing of Waterloo Bridge has had an influence extending well beyond the Embankment and Westminster Bridge; and the effects of a breakdown on the Underground may be felt in every corner of the city. London has been allowed to grow under no special plans. Much of its charm lies in the disorderly sprawling of its streets. Few of them are straight and hardly any of even width throughout. Some—nor are they the least important—are narrow and crooked, like Bond-street and Fetter-lane. Railways with an insufficient number of tracks penetrate on overbridges into the heart of the city to the detriment of architectural effect, but the convenience of passengers. Several of the bridges across the Thames, each in itself necessarily a bottle-neck for traffic, are poorly served by approach roads. Although the main plan—or lack of plan—is unalterable, there is scope for improvement in the driving of new roads, such as Kingsway, or in the widening of old ones. A great profusion of suggested schemes exists, from purely minor affairs to such grandiose conceptions as the diversion of the Thames and the use of its dry bed as a great artery for traffic by road and rail. Many of these schemes have been advocated for years by responsible people. One of them is that for a bridge at Charing Cross. Many of them undoubtedly will sooner or later in some form of modification be carried out. But at present few of them have any sort of official backing of such a kind that preparation by the non-renewal of building leases and in similar ways can be made. A systematic survey of the highway developments required in order to keep pace with the expansion of traffic has become necessary, so that this lack of official backing may be remedied. Mr. C. H. Bressey, Chief Engineer of the Ministry of Transport since 1928, who has for fifteen years been associated with the planning and construction of roads in the London area, has been appointed to make such a survey. So that the architectural possibilities of any plans that may be considered shall not be overlooked, Sir Edwin Lutyens is to act as consultant to Mr. Bressey.

Wide terms of reference have been given to Mr. Bressey for the conduct of his work. They are, "to study and report upon the need for improved communications by road (including the improvement and re-modelling of existing roads) in the area of Greater London, and to prepare a highway development plan for that area, incorporating so far as is practicable and desirable schemes already planned or projected." "Highways" is taken to include tunnels, viaducts, and bridges. Not only has Mr. Bressey to study the roads themselves, but also the traffic that uses them and to attempt to decide whether that use is justified. He will need to keep a due balance as between the needs of arterial roads leading to other parts of the country and the requirements of "veins" along which the daily pulse of traffic from and to the suburbs may take place. Many matters will come within his view; ribbon development, the siting of railway

stations and access to them, the provision of suitable access to the docks and to works in the neighbourhood of London, the restriction of certain classes of traffic to particular hours of the day or to particular routes, to mention but a few. But an essential part of his task will be the attempt to forecast conditions of the future and so to plan London that, as the years go by and his schemes come to fruition, congestion will grow less. Upon the success of his forecast and the willingness of the Government in power to carry out his recommendations may depend the future prosperity of London.

The New Fulham Power Station.

No. I.

UNDER the South-East England electricity scheme the Fulham Borough Council's electric generating station was scheduled as a selected station for the generation of current for the Central Electricity Board, which on August 3rd, 1929, entered into an agreement with the Council under which the latter undertook to extend and alter the existing station and to acquire certain lands for that purpose. According to the agreement, the ultimate capacity of the extended and altered station was to be 250,000 kW, while the first section was to have a capacity of 120,000 kW. But as the existing station had to remain in use until the first section of the new plant was completed, it became apparent that the best policy would be to build an entirely new station on the newly acquired land.

The consent of the Electricity Commissioners was, of course, necessary before the new station could be erected, and a local inquiry was held by the Commissioners in December, 1930, at which evidence for and against the proposal was given. The principal objections that were raised were from the London County Council, the City of Westminster, and the Boroughs of Kensington and Chelsea. Briefly, the objections were based on fears that the station would be detrimental to the health and amenities of the adjacent areas by reason of smoke, grit, and sulphur emissions. While precautions of a more or less satisfactory

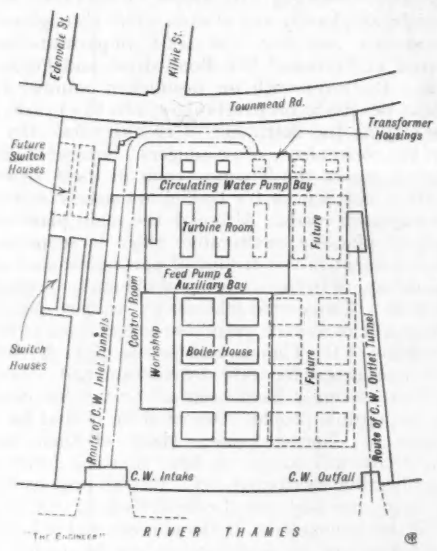


FIG. 1—PLAN OF STATION

character had been taken at that time by owners of some power stations to prevent smoke and grit nuisance, nothing had been done to eliminate sulphur oxides from chimney gases. No data were therefore available on which to design and manufacture a satisfactory sulphur elimination plant. To enable it to submit concrete proposals to the Electricity Commissioners, the Council installed an experimental gas-washing plant in the old station in Townmead-road, and although it was primarily designed for grit and dust elimination, sufficient success was obtained in connection with sulphur elimination to enable the Council to guarantee that the new station would not give rise to the troubles which the London County Council and others contemplated.

In consequence of the public inquiry, the Electricity Commissioners gave their formal consent to the erection of a new station with an initial capacity of 132,000kW, and an ultimate capacity of 318,000 kW. The Council appointed Messrs. Preece, Cardew and Rider, of Westminater, and Mr. Arthur J. Fuller, the Borough consulting and electrical engineer, to act as joint consultants for the design and construction of the station. For assistance in connection with the civil engineering and building work, these consultants subsequently secured the services of Sir H. H. Dalrymple Hay, Messrs. Mott Hay and Anderson, and Messrs. S. H. White and Son. Dr. R. Lessing was called upon to give advice on the elimination of sulphur and grit; whilst Mr. H. Clarke was appointed resident engineer on behalf of the joint consulting engineers.

New sites adjacent to the original station were purchased by the Council which also secured possession of leased sites already belonging to it, giving with the ground occupied by the old power house, which will ultimately be demolished, an area of about 10½ acres with a river frontage of about 1180ft. As it was necessary to reinstate firms whose land had been acquired by the Council on other sites, it was not until September, 1932, that the Council was able to begin the work of demolition of old buildings and clearing the works in readiness for the construction of the station foundations. Meantime, considerable work had been done in the way of preparing plans and the drafting specifications for the plant that would take the longest time to manufacture.

Ultimately the station, of which we give a plan in Fig. 1, will contain five 60,000-kW turbo-generator sets and sixteen boilers, each capable of evaporating 260,000 lb. of water per hour, but the initial plant, which is now being installed, will consist of two turbo-alternators and six boilers. There will also be a 10,000-kW house service set. The steam pressure will be 625 lb. per square inch and the steam will be superheated to a total temperature of 850 deg. Fah. The main alternators will generate at 11,000 volts, which will be stepped up to 66,000 volts for feeding into the transmission system of the Central Electricity Board. As shown in the plan, each boiler-house will ultimately contain eight boilers in two rows, and each boiler will have its own gas-washing equipment. There will be four 300ft. reinforced concrete chimneys, but only two will be provided for the first section of the station now under construction. Coal will be brought to the station by colliers of about 2000 tons capacity, or, alternatively, by barges, which will be accommodated at a jetty built in the river. At the time of writing, the contract for the coal-handling plant has not been placed, and exact details of the equipment are not available, but the coal will, of course, be unloaded by electric cranes, and after it has been weighed it will be transported either directly to boiler-houses or to a coal storage dump on the site, from which it will be taken to the boiler-houses when required. From large service coal bunkers in each boiler house coal will be fed to the furnaces by gravity.

Circulating water for the condensers will be taken from and returned to the river Thames at the rate of about 14 million gallons per hour at times of full load. Two tunnels, with a diameter of 9ft. 6in., have been driven from the river to a central distributing chamber near the condensing water pump bay, from which the pumps will draw the water and deliver it to the condensers, the inlet tunnels being at a depth which allows the water to flow by gravity from the river to the station through coarse and fine mesh self-cleaning screens. The water discharged from the condensers will be returned to the river through a single 10ft. 6in. diameter tunnel with the outlet some 320ft. down the river.

An idea of the appearance of the building a short time ago can be gathered from Fig. 2, which shows the steelwork in the course of erection. The boiler-house, in which the first six boilers are being erected and in which there is space for two other units, together with all the economisers, air heaters, gas-washing plant, forced and induced draught fans, ash plant, and usual auxiliaries, measures approximately 240ft. by 160ft. In due course another boiler-house of the same size will be added to accommodate, as already mentioned, eight additional boilers of the same capacity. The feed pump bay, which will house the main steam distributors, steam lines, feed pumps, and feed lines, H.P. feed heaters, evaporators, de-aerators, surge storage and raw feed-water tanks, and hot wells, measures 42ft. by 224ft., whilst the turbine room for the two first 60,000 kW main generating units, 10,000 kW house set, and all the auxiliaries, measures 192ft. by 105ft., and is served by a 120-ton overhead travelling crane, supplied by the Clyde Crane and Engineering Company, Ltd. Space is available for another 60,000 kW set, but when the time arrives for the installation of the last two units the turbine room will be extended. In the basement of the circulating water pump bay, which measures 192ft. by 31ft., and which will be served by a 15-ton crane, the circulating water pumps will be erected and the administration offices will be above them. As shown in the plan, the transformer housings for the main transformers connected to the main generators and for certain auxiliary transformers, together with the cooling plant, are adjacent to the circulating water pump bay, and between these housings and the Townmead-road there is a roadway giving access to the station. On the south side of the boiler-house now under construction is a workshop measuring 175ft. by 48ft., and above it there is accommodation for laboratories, stores for records, &c. At the south-western extremity of the station there are switch-houses which will contain 66 kV generator, feeder and reactor switches in duplicate, the control room for these switches being between these switch-houses and the southern end of the turbine room, and forming a bridge between the latter and the switch-houses.

The steel framework of these buildings was fabricated and erected by Dorman Long and Co., Ltd. Some 9000 tons are contained in the boiler-house framework. The stanchions are of plated construction, and 12in. by 12in. angles and flange plates up to a thickness of 3in. were largely employed. They are made up of special lengths up to 45ft., some of the lengths weighing as much as 35 tons. The feed pump bay is framed by a double line of stanchions founded on a single continuous grillage covering the whole bay area. There are three tiers, the lowest being composed of 28½in. by 9in. compounds, 72ft. long. The intermediate tier is composed of 29in. by 9in. compounds, and the top tier of plate girders with 54in. webs. Mild steel slabs or blooms up to a thickness of 11½in. and a weight of 4·25 tons have been used to spread the load from the stanchions on to the grillage members. The approximate weight of the complete grillage is some 2700 tons. Heavy portal frames are provided on all floors throughout this bay in each direction of the building to resist wind pressure. The total amount of steelwork in the feed pump bay is 7000 tons; in the turbine room and circulating water pump bay 1550 tons; in the switch-houses 1500 tons, and in the workshop 400 tons. Some of the cranes used for the erection of the steelwork were employed in the construction of the Sydney Harbour Bridge.

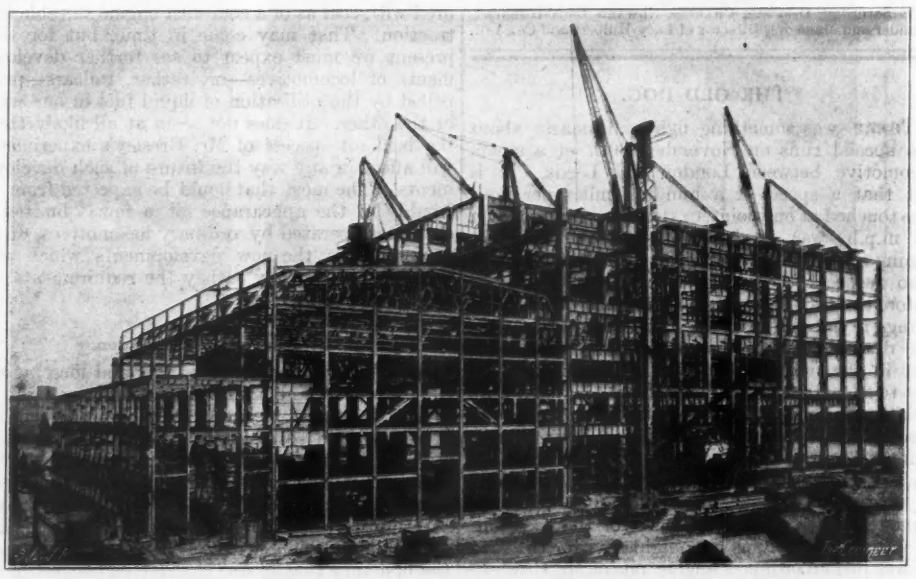


FIG. 2—BUILDING IN COURSE OF CONSTRUCTION

The largest single pieces in the steelwork construction are the eight coal bunker girders, each of which is 55ft. long by 10ft. deep, and weighs 60 tons. The number of rivets driven on site was approximately 250,000, apart from the use of many thousands of turned bolts.

The tube arrangement of the six Stirling boilers—Figs. 3–5—now being installed, is sixty-two wide and nineteen deep. Exclusive of the water walls the heating surface of each unit is 22,680 square feet. The pressure at the superheater outlet will be 683 lb. per square inch, and the steam temperature 850 deg. Fah. The M.C.R. rating of each unit is 260,000 lb. per hour. All the drums are of forged construction, the inside diameter of the front drum, which is 3¼in. thick and weighs 28 tons, being 42in. The rear steam drum has an inside diameter of 54in., is 4⅜in. thick, and weighs 52 tons, whilst the mud drum is 54in. in diameter, is 3⅞in. thick, and weighs 42 tons. There are 1139 main generating tubes with an outside diameter of 3¼in. and 4 I.W.G. and 5 I.W.G. thick. Each boiler is being fitted with a Taylor retort stoker for burning the usual kind of coal that is sea-borne into the Thames Valley, having a calorific value of between 10,000 and 14,000 B.Th.U's per pound, and an ash content varying between 5 and 15 per cent. Each stoker consists of eighteen retorts, giving a width between the side walls at the stoker level of 31ft. 5½in. The length of each retort is 15ft., so that "green" coal will be fed upwards into the fire at various points over a 15ft. length of the grate.

Primarily the stoker structure consists of inclined steel plate girders on which all the cast iron parts which are subjected to the heat of the furnace rest. At normal evaporation each stoker will burn 14 tons of 11,000 B.Th.U's coal per hour. A crusher pit approximately 5ft. 3in. wide and 6ft. 9in. deep, is being provided at the rear of each stoker, and during operation it will be kept full of refuse for, as is well known, the crusher rolls which operate intermittently simply grind out sufficient ash at the bottom to maintain the proper level at the top, the amount of refuse stored being approximately 20 tons. When a boiler is steaming at 260,000 lb. per hour, the time interval which will elapse between the feeding of a particle of ash to the top of the pit and its ultimate discharge by the rolls is ten hours. During this period the ash is "soaked" in the pit to which air is continuously admitted under pressure—a process which permits of the almost complete recovery of carbon from the refuse at any load within the operating range without impairing the high CO_2 performance of the stoker. The crusher rolls are driven at each end of the crusher pit, and each drive operates two rolls equal in length to half the width of the furnace. By rotating away from one another the rolls grind the ash against the crusher plates, which can be adjusted to maintain control of the size of the ash discharged and the level of the refuse at the top of the pit. Additional flexibility of control can be secured by operating one roll faster than the other, or by operating two half-rolls on one side of the furnace faster than those on the other side. While it is difficult to predetermine the speed at which the crusher rolls at the bottom of the pit will operate, in all probability the speed will be within the limits of two and six revolutions per hour. At normal evaporation the stoker crank shaft which operates the fuel-feeding rams will work at approximately 2½ r.p.m. The torque is transmitted to the stoker crank shaft through spur gear-boxes from the stoker speed shaft, which is driven by the electric motor.

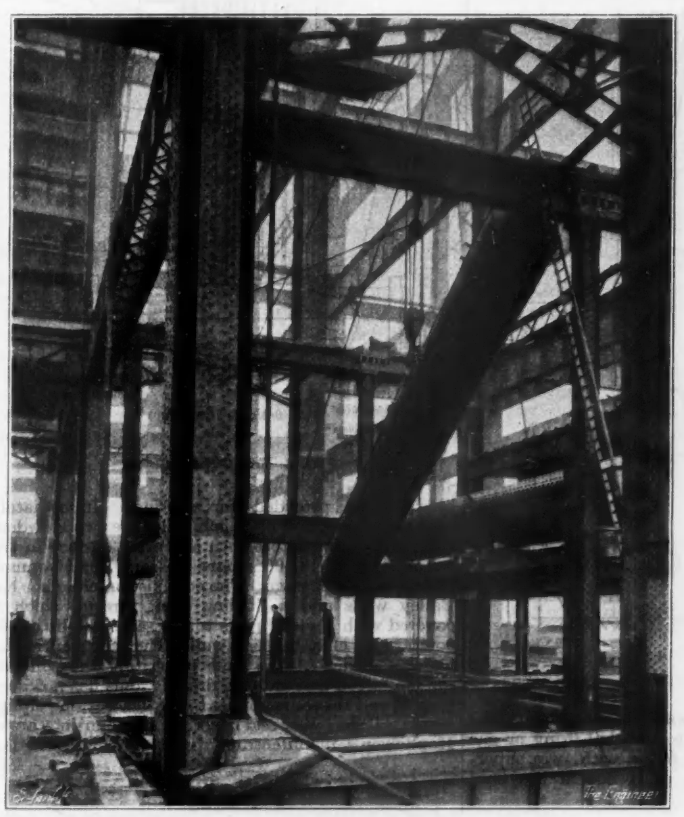
When the box is in low gear the speed reduction is 287 to 1, and when in high gear 191 to 1. The crank shaft drive is divided into five groups, two, each driving three retorts and three, each operating four retorts. There is one power box for each group, and all the boxes are operated from the common speed shaft. By means of this sectionalised drive, and by adjusting the gear shift levers on the power boxes, it is possible to operate any number of groups of feeding rams faster or slower than the other groups, whilst by placing any given gear-box or boxes in neutral the operations of some sections of the stoker can be discontinued. For any particular speed of the speed shaft, the power boxes thus enable the operator to adjust the feed of the fuel across the grate. The power boxes contain a planetary system of gears, composed entirely of spur wheels, and when it is necessary to change gear the operator merely shifts the lever on a box to the "high" or "low" position, which has the effect of locking one or the other of two planetary rings, the spur wheels being in mesh all the time. A master shearing pin for each of the five driving sections serves to protect the stoker mechanism. There are also individual sharing pins on each pusher rod and on the crusher roll drive. The diameter of each of the fuel feeding rams is 9in. and the stroke 9½in., there being four pushers at the bottom of each retort. Facilities are provided at the front of the stoker to enable the operator to regulate the movement of each pusher for any given stroke up to a maximum of 9in.

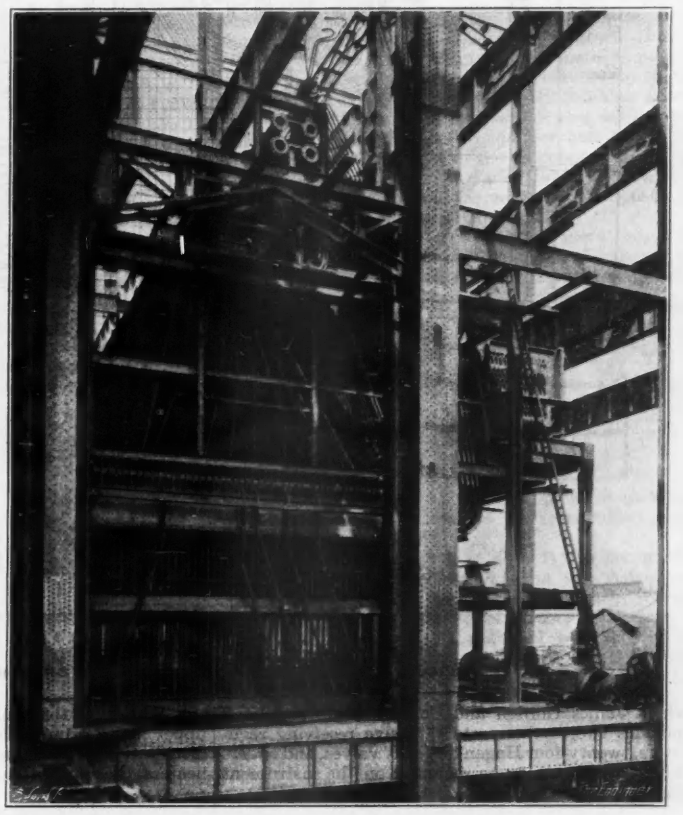
The "Me Le Sco" superheaters will operate in conjunction with de-superheaters, and will be automatically controlled to maintain 850 deg. Fah. at the outlets at all loads from 150,000 lb. to 260,000 lb. actual evaporation per hour. By reason of the fact that it is characteristic of a convection superheater for steam temperatures to increase with the load, the superheater has to be large enough to give the temperature stated at the 150,000 lb. load and a surface of 9600 square feet per boiler has been provided to meet that condition. Other factors may result in increased steam temperature, such as the practice of operating with a low feed temperature, increase in excess air for combustion and a decrease in furnace wall and boiler front bank heat absorption, owing to slagging or sooting up after periods of service. The control gear being provided by the Superheater Company, Ltd., will, however, it is claimed, take care of such variations, and the steam temperature at the turbines will be maintained at the maximum permissible value.

If the prime movers alone required protection against unduly high steam temperatures, the control apparatus might be placed in the main steam ranges in order to adjust the steam temperature after leaving the superheaters, but with an operating temperature of 850 deg. it is necessary to safeguard the superheater itself against overheating. Control will therefore be carried out within the superheaters, so that at no time will any part of the apparatus be subjected to a temperature above the maximum value permissible. The use of expensive alloy material for the high-temperature portions of the elements is therefore unnecessary, and ductile steel tubing may be employed.

A cross section of the superheater and non-contact de-superheater arrangement is given in Fig. 6. Fig. 7 is a diagram showing the assembly; whilst Fig. 8 shows a de-superheater in detail. Two "Me Le Sco" superheaters are provided for each boiler, each with its own inlet and outlet, and each divided into primary and secondary sections. The steam is initially superheated in the primary superheater and after passing through the de-superheaters or through a by-pass, it enters the secondary superheater, from which it passes to the main steam range. The headers and all the branches and flanges are machined from solid steel forgings, the joints of the elements to the headers being of the "Concen" metal to metal and cone construction. Constructed in accordance with the "Me Le Sco" process, the superheater elements have their upset ball ends and return bends integrally machine forged from the metal itself, thus giving a homogeneous construction from end to end. The primary elements are composed of ordinary low carbon mild steel tubing, but the secondary elements which are subjected to the highest temperature conditions are made of low carbon steel, with about 0·3 per cent. content of copper and molybdenum. There are two de-superheater controls per boiler, or one for each superheater. The de-superheaters are interposed in the steam flow between the primary and secondary superheaters and a Hagan Venturi butterfly valve controls the amount of steam flowing through each of the de-superheaters, which are also by-passed, the control being obtained by a similar type of valve to that mentioned. The outlets from the de-superheater and the by-pass are connected together so that the steam is mixed before entering the secondary superheater. Definite control of the required amount of steam flow through each de-superheater is obtained by linking the two butterfly valves together, so that as one opens the other closes.

The butterfly valve positions are governed by a Hagan thermostat, Fig. 9, supplied by James Gordon and Co., Ltd. The thermostat, which is sensitive to very slight variations in steam temperature, is placed in the steam pipe line leading from the outlet of the secondary superheater to the main range, and controls a supply of air and the pressure acting on a diaphragm, which regulates the position of pistons in a compressed air cylinder of the receiving regulator, Fig. 10, which governs the movements of the butterfly valves. The control pressure bears a definite relation to the steam temperature and the crosshead of the regulating pistons takes up a position corresponding to the pressure received. With a rise in temperature, the butterfly valves are moved to allow an increasing





FIGS. 3 AND 4—BOILERS IN COURSE OF ERECTION

amount of steam to pass through the de-superheater until the required temperature at the thermostat is obtained, whilst with a fall in steam temperature the operation is reversed and more steam is made to flow through the by-pass. The regulating equipment which James Gordon and Co., Ltd., are supplying includes twelve thermostats, twelve receiving regulators, twenty-four Hagan butterfly valves, and twelve relays, which are to be mounted on the instrument panels for remote manual operation.

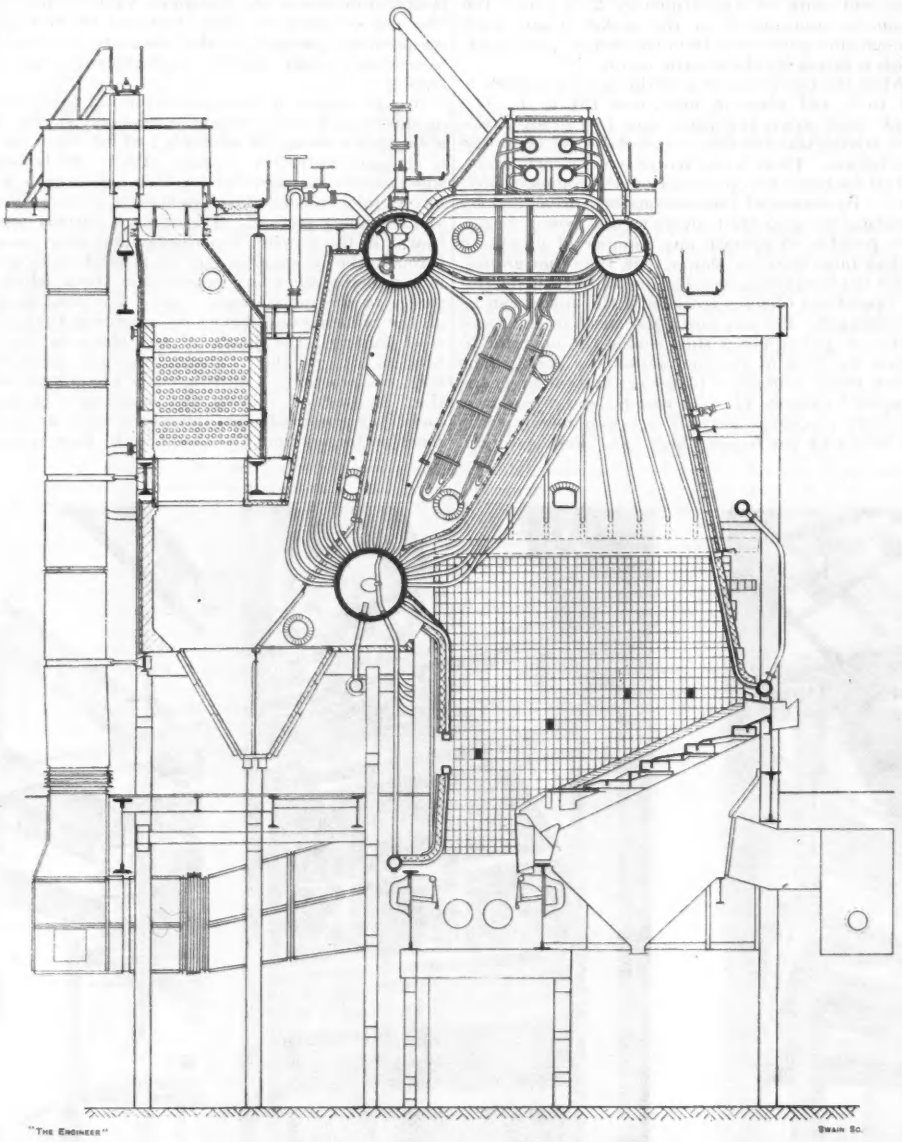


FIG. 5—CROSS SECTIONAL ARRANGEMENT OF BOILER

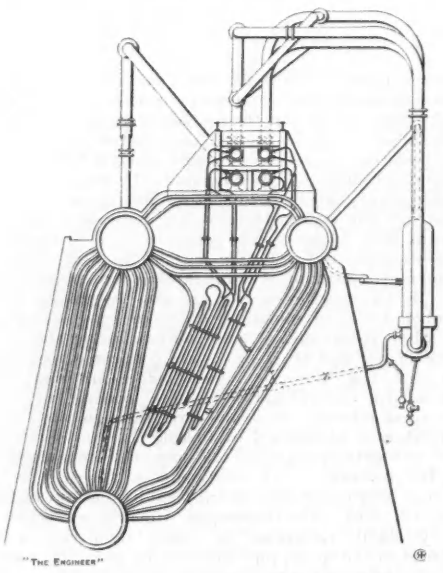


FIG. 6—ARRANGEMENT OF SUPERHEATER AND DE-SUPERHEATERS

The de-superheater shown in Fig. 8 consists of an upper mild steel shell machined from a solid forging, and a lower base composed of cast steel containing 0·5 per cent. molybdenum, a Vickers-Anderson joint connecting the two parts. The tube plate in which the de-superheating tubes are expanded is cast integral with the base. As the de-superheater is connected by pipes with the upper and lower drums of the boiler, and is placed so that its working water level coincides with that of the boiler, its tubes are entirely submerged and the steam generated by evaporation of the cooling water is returned to the upper boiler drum. Owing to unequal firing or gas distribution, it is commonly found with twin superheaters that a considerable difference in the final

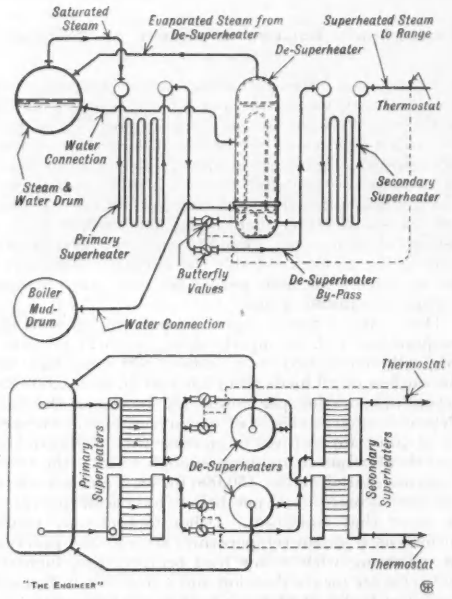


FIG. 7—DIAGRAM OF SUPERHEATERS AND DE-SUPERHEATERS

steam temperature exists between one side and the other, but by crossing over the piping connections from the left-hand primary superheater and de-superheater to the right-hand secondary superheater, and *vice versâ*, the temperature difference is more or less corrected as the steam flows primarily through a zone of one gas condition and then through the opposite side. In this way control steps occur simultaneously instead of earlier on one side than on the other, as would be the case in the event of unequal conditions prevailing, and if the cross-over connections were not provided.

Behind each boiler is a Foster gilled tube type non-steaming economiser with a heating surface of 14,700 square feet, and containing 196 tubes arranged fourteen high and fourteen deep, the length of the tubes being 25ft. 6in. Four single-nozzle Babcock

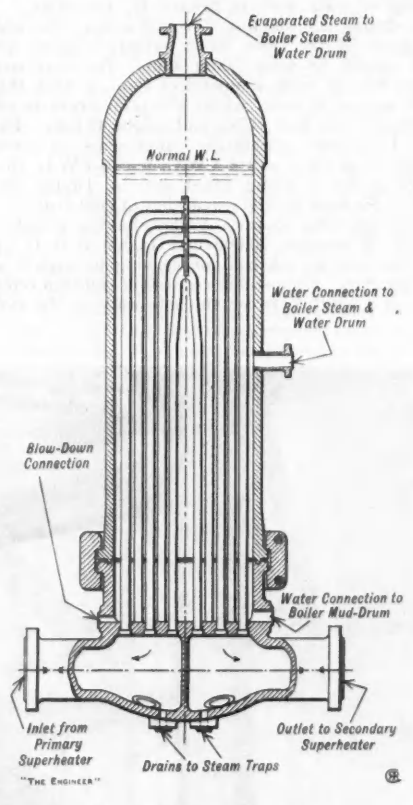

Evaporated Steam to Boiler Steam & Water Drum
Normal W.L.
Water Connection to Boiler Steam & Water Drum
Blow-Down Connection
Water Connection to Boiler Mud-Drum
Inlet from Primary Superheater
Drains to Steam Traps
Outlet to Secondary Superheater
"The Engineer"

FIG. 8—DE-SUPERHEATER

blowers are provided for sooting. Immediately above the economiser on each boiler are two Howden-Ljungström preheaters with a heating surface in the gas passage of 18,100 square feet and 16,400 square feet in the air passage. The combustion chamber has Bailey walls and a Stirling front screen, which is covered with Bailey bricks to the same height as the combustion chamber side wall. The rear wall is also water cooled. At the time of writing the contract for the forced and induced draught fans has not been placed, and the same applies to the gas washing equipment. All the boiler and superheater mountings are of Hopkinson's manufacture, whilst the high and low

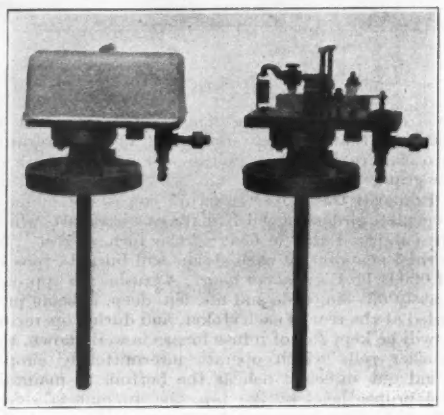


FIG. 9—HAGAN THERMOSTAT

water alarms are being supplied by Dewrance and Co., Ltd. Three Babcock Clyde single-nozzle blowers are installed in the front wall for sweeping the front bank of tubes and five multi-jet blowers of the same make are provided on each side wall of the boiler. The temperature of the feed to the economiser will be 350 deg. Fah., that to the boiler at maximum evaporation 480 deg. Fah., and at 150,000 lb. evaporation 418 deg. Fah. The escaping gas temperature at the boiler damper will be 740 deg. Fah., at the economiser outlet 510 deg. Fah., and at the air heater 240 deg. Fah. At maximum load the temperature of the air supplied to the furnace will be 400 deg. Fah., and at 150,000 lb. evaporation 320 deg. Fah. Based on the gross calorific value of the coal fired, the combined efficiency of the boiler, superheater, and air heater will be 86 per cent.

For handling the ashes a " Hydrojet " high-velocity sluice equipment is being supplied by the Ash Company (London), Ltd. After passing through crushing rollers the ash from the stokers will be quenched and stored in hoppers extending down to within 18in. of the basement level. To give resistance to the corrosive action of the quenching water the hoppers will be composed of unmachined cast iron panel plates fitted by external lugs and bolts to a steel framework and lined internally with fire-bricks, each three or four

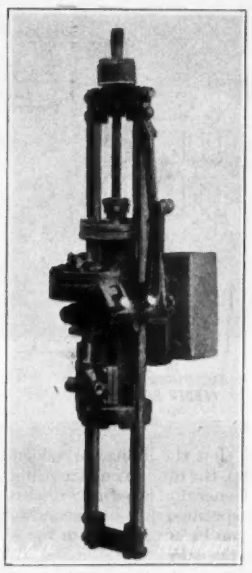


FIG. 10—REGULATOR

rows of which will be supported by shelves cast integrally with the panel plates so that damage will be localised, thus making it possible to replace faulty bricks with ease. The bottom of each hopper will be formed by an inclined feed plate on which the ash will rest and from which it will be fed out periodically when the hopper is full by means of a hand-controlled feed nozzle which will project a high-velocity jet of water up against the pile of ash, thereby agitating it and washing it down off the feed plate in a regular and controllable manner. Below each line of hoppers there will be a high-velocity " Hydrojet " sluiceway, into which the ash will be fed in the manner described from the hoppers. The sluices used with this system of ash handling run horizontally and depend on high-pressure water to maintain the flow. By means of booster nozzles the water is introduced at appropriate points along the length of the sluice, the pressure of the water both for the feed and sluice nozzles being 100 lb. per square inch, whilst the issuing velocity from the nozzles is approximately 120ft. per second. As the energy per gallon in a stream of water, and hence its moving power, is proportional to the square of its velocity, it is evident that at the feeding points, where the booster nozzles are situated, the capacity of a Hydrojet sluice is many times greater than that of a low-velocity system operating at, say, 10ft. per second. No matter how high the velocity may be, however, if a large quantity of clinker be suddenly dumped into the sluice clogging would occur, and it is for this reason that the combination of the inclined feed plate and feed nozzle is employed. When used with a high-velocity sluice this method is said definitely to eliminate clogging.

The sluiceway will be composed of half-round nickel cast iron sluiceway liners sprung into position against the walls of a rectangular concrete trench closed by self-sealing cast iron cover plates. At the ends of the boiler-house each longitudinal sluice will discharge into a cross sluice and the two cross sluices will finally convey the material to a central sump sunk in the floor of the boiler-house basement. By means of nozzles using the same high-pressure water as employed for handling the ash the material from the riddlings hoppers below the stokers will be ejected through pipes into the sluiceway. One of two vertical spindle " Hydroseal " pumps will be employed alternatively for re-circulating the high-pressure water for the feed and sluice nozzles from the sump, and as it is impossible to screen out all gritty material from the water, the pumps are designed to withstand abrasive action by making the wearing parts of a special hard alloy and by providing clean water sealing arrangements, giving a constant leak of clean water inwards instead of a leak of gritty water outwards past the fine clearances between the rotating and stationery parts. After being discharged from the cross sluices the ash water mixture will be transferred from the sump to the outside of the boiler-house by means of one of two vertical spindle " Hydroseal " ash pumps, also designed to resist abrasion and to maintain their efficiency.

(To be continued.)

Bus-Bars for Outdoor Sub-Stations.

No. II.

By A. M SPRUCE, A.A.I.E.E.

(Continued from page 564, December 7th.)

CABLE DIAMETERS FOR BUS-BAR FITTINGS.

THE simplest and most compact form of cable stranding is the concentric lay. It consists of a single strand running through the centre of the cable, round which are laid successive layers wound spirally in opposite directions. The method employed for calculating the diameter assumes that all the strands are of the same gauge, which, of course, is usually the case for copper and aluminium wires, but not always for A.C.S.R. cables.

If D is the strand diameter, then the number of wires that can be placed round the centre single strand is $2\pi D/D$, which gives a maximum of six wires, since the fraction of a wire must be neglected. Similarly, in the second layer, $4\pi D/D$ strands may be placed on the cable, *i.e.*, twelve wires. So that for each successive layer six more wires may be applied than in the preceding layer, giving the total number of wires in standard cables as 1, 7, 19, 37, 61, 91, or 127.

The overall diameter of stranded cables may, therefore, be computed by multiplying the diameter of one strand by the following constants :—

No. of wires.	Constant.
3	2·15
7	3·0
19	5·0
37	7·0
61	9·0
91	11·0
127	13·0

HOLLOW CONDUCTORS FOR E.H.V. STATIONS.

On extra high-voltage systems the diameter of the conductors must be sufficiently large to limit the formation of corona, but as voltages increase the cross-sectional area will decrease, owing to the reduced current to be carried. In order to obtain the combination of large diameter and small area hollow conductors have been developed. Aluminium conductors raise the value of the critical voltage to a certain extent above that of the equivalent copper section, because of the greater cross-sectional area required for the same current-carrying capacity. A.C.S.R. cables also have large diameters for equivalent copper sections, but, in consequence of the difference in the coefficients of expansion of the two metals, complications arise in the distribution of loading between the steel and aluminium with variations of temperature. However, the small spans and relatively low tensions employed for outdoor station buses make these complications less exaggerated than on transmission lines. Reference may be made to other articles dealing with this subject in detail.[6]

In the United States a stranded hollow-type copper conductor has been used for some years with success. It is built up of concentric layers of stranded wires supported on an I-section copper beam running down the centre of the cable.

Recently, a single-layer, multi-section, dovetailed-type of hollow conductor has been introduced into the States by the Department of Water and Power, City of Los Angeles, California, for the Boulder Dam project. This type of conductor, which resembles more or less a flexible copper tube, is manufactured in two general types, viz., a cable with two layers of flat wires wound in opposite directions on a T-section reinforcing spiral element, and a single-layer, dovetailed, sectional type without reinforcing element. Extra high-voltage installations of 220 to 380 kV have been in commission some five or six years in Germany and Italy using these conductors.

With the initiation of the 132-kV British grid scheme came also the development of special conductors for use on the high-voltage outdoor sub-stations. In the early erected stations the connections were made with a cellular type of conductor composed of a number of hollow copper tubes made up of strip bent in circular form with an open joint and manufactured in lengths up to half a mile. The cross-sectional area is 0·3 square inch when using thirty-seven hollow tubes, and a breaking load of 12,700 lb. is obtained.

The use of this cellular type of conductor having a fairly large diameter, and a copper cross section that is uniform from the centre to the outside of the cable, is not altogether ideal for carrying alternating current. The resistance of a conductor carrying an alternating current is higher than for the same conductor at the same temperature when carrying direct current, owing to the phenomenon known as " skin effect," and in order to reduce this effective A.C. resistance a concentration of copper may with advantage be placed on the outside of the cable where the current tends to flow.

In addition to skin effect, a non-uniform distribution of current in a conductor results from its proximity to another phase conductor, owing to the mutual inductance between the two. This is of most importance in long bus-bars carrying heavy currents at low voltage. The flux due to the current in one conductor cutting the adjacent bar tends to crowd the current into those portions of the conductors nearest to each other, resulting in the so-called " proximity effect."

In general, proximity effect is directly proportional to the value of the current and inversely proportional to the separation of the conductors. Consequently, with the phase clearances necessary on high-voltage stations and with the relatively small currents this effect is not of great importance. The limiting value of conductor separation at which proximity effect may be neglected appears to be between 12in. and 16in. for current values of about 1000 to 1500 ampères. The effect is very noticeable in metal-clad switchgear designs, cables and the windings of A.C. machines.

On the South-East England 132-kV outdoor stations a cable similar to the cellular type is used, but with the outer tubes replaced by eighteen strands of solid copper. By this means the metal is placed in the best position for carrying current. Two layers of brass tubes wound concentrically round a single centre tube form a base on which the solid outer strands are wound. The weight per foot run is, of course, greater than that of the all-copper tube type, but the conductor is so designed that the area and overall diameter remain the same as previously at 0·3 square inch and 1in. respectively.

Another type of hollow conductor, more simple in construction than the cellular cables, is shown in Fig. 2. It has been used on a number of C.E.B. sub-

FIG. 2

stations in the Central England and South-West areas, both for the strained and unstrained connections.

The cable is made up of 46 H.D. copper wires, each 0·093in. diameter, stranded in two concentric layers of twenty and twenty-six wires each, wound round a specially formed helical centre of H.D. copper strip. The conductor is patented by the Pirelli-General Cable Company and has the following characteristics :—

Nominal sectional area of conductor	0·3 sq. in.
Overall diameter	0·905in.
Centre copper supporting strip	0·2×0·03 inch
Pitch of helix	0·375in.
Weight of conductor per 1000ft.	1297 lb.
Resistance per 1000ft. at 16 deg. Cent.	0·0274 ohms max.
Tensile breaking stress of material	62,720 lb. per sq. in.
Ultimate strength of complete conductor	17,640 lb.
Elongation in length of 10in.	2 per cent. max.

The sub-stations in the Central England area and a number on the South-West scheme using this type of cable were equipped by the General Electric Company to the specification of the Central Electricity Board. On the C.E. scheme the various types comprise H.D.B. (high double bus-bar), L.N.E. (low non-extensible), H.E. (high extensible), and L.D.B (low double bus-bar) designs.

The L.D.B. type of station is installed at Wolverhampton. The bus-bar system and interconnections for a feeder and transformer section are illustrated in Fig. 3. A maximum tension of 2000 lb. under the worst loading conditions was allowed for in the design of the strained bus-bars.

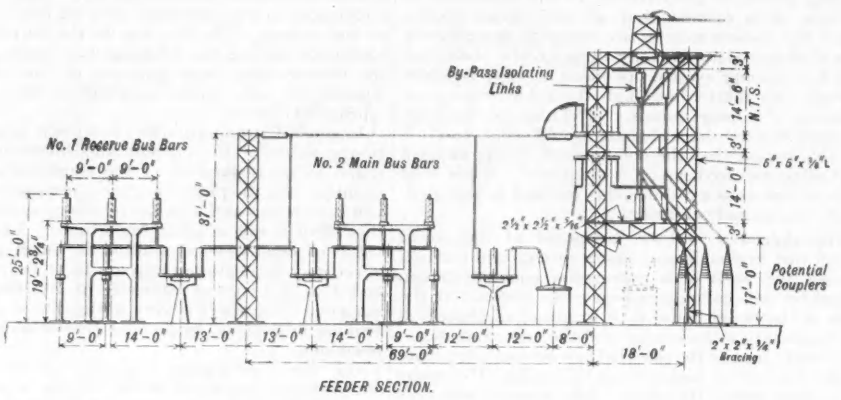
FUNDAMENTAL PARABOLIC FORMULÆ FOR STRAINED BUS-BARS.

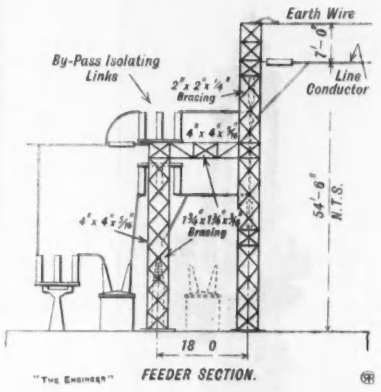
Consider a uniform and perfectly flexible conductor strung between two supports at the same elevation. If the weight of the insulators at each end be neglected, then the resulting curve will take the form of a catenary. The tension at any point along the conductor always acts in the same direction as the conductor at that point, with the maximum tension occurring at the supporting points and the minimum at the lowest point. The total tension, therefore, varies according to the position in the cable, and may be divided into two components : (*a*) a horizontal component which is uniform throughout the cable length, and (*b*) a vertical component which varies along each half of its length.

With supports at the same elevation the vertical component of the tension at any point is equal to one-half the weight of the conductor in the span minus the weight of the conductor between that point and the nearest point of support. Thus, at the lowest

point one-half of the conductor weight acts between this point and the support, so that the vertical component is zero and the whole tension is horizontal.

For an exact mathematical analysis of the forces occurring in a conductor suspended between two fixed points the complicated hyperbolic functions of the catenary must be employed, but if the conductor weight is uniformly distributed along a horizontal line between the points of support, the parabolic formula may be used. With the small spans on outdoor sub-stations the error introduced by the substitution of the parabolic for the catenary curve is negligible. In fact, for most transmission lines where the sag is not greater than about 10 per cent. of the span, and the span does not exceed 1000ft. to 1500ft., this substitution is permissible.





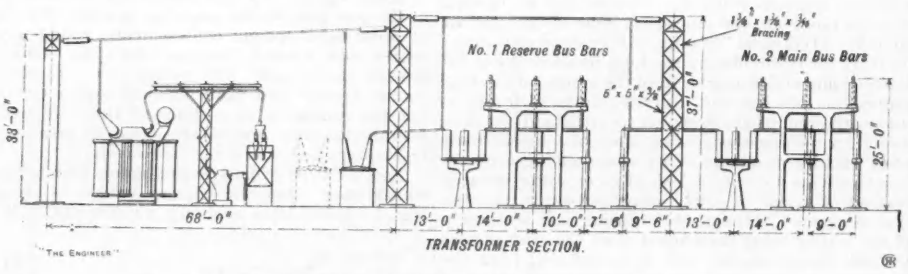


FIG. 3—BUS-BAR SYSTEM AND INTERCONNECTIONS

Fig. 4 illustrates a conductor strung between the two points A and B and shows the various forces acting and their points of action. The standard well-known formula for a parabola is $x^2=4\,a\,y$ and here $x=l/2$ and $y=S$.

Consider the equilibrium of the R.H. portion C B of the conductor which has been cut at C and the horizontal force T applied to keep this portion in equilibrium. The force F at the point of support may be divided into two components, viz., F_h and F_v, acting horizontally and vertically respectively. The direction of force F is such that $\theta=\tan^{-1} F_v/F_h$. Let w equal the weight per foot run of the conductor

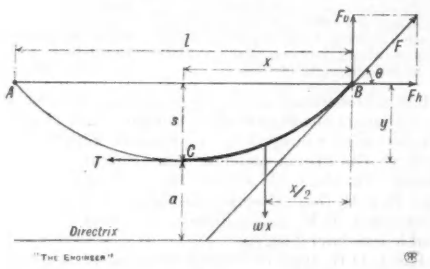


FIG. 4

(plus any external loading if this should occur), then $w\,x$ will be the weight of the portion under consideration and may be assumed to act, without serious error, at a distance $x/2$ from the vertical through B. To maintain C B in equilibrium the two vertical forces $w\,x$ and F_v must be equal and act in opposite directions, so also must the two horizontal forces T and F_h.

Taking moments about the point B, we have

$$T\,.\,y=w\,x\,.\,x/2=w\,x^2/2$$

or $$y=w\,x^2/2\,T,$$

which defines a parabola and gives the sag at any point. Substituting in this equation the values of x and y, we obtain the maximum sag as

$$S=w\,l^2/8\,T.$$

From this equation it is seen that for a constant tension T in conductors in two different spans, the sag varies directly as the square of the spans, or, for equal sags the tension is inversely proportional to the square of the spans. Note that l and S are in feet, and T and w in pounds.

The structural members supporting strained connections should be designed to resist force F, but as this is generally unknown the tension T is taken. The maximum value of T under worst loading conditions is the breaking load of the conductor divided by an appropriate factor of safety. Actually, in practice, there is very little difference in value between F and T, the difference approximating to the weight of a length of conductor equal to the sag. So that with the assumptions made for material properties and loading conditions, this difference is of little consequence.

Neglecting the weight of the insulators, we may express the relation between F and T in symbols as

$$F=T+w\,S,$$

or, maximum tension

$$F=\frac{w\,l^2}{8\,S}+w\,S.$$

With the symbols as given in Fig. 4, we also have the following derived formulæ for a parabola :—

Length of conductor

$$L=l+\frac{8\,S^2}{3\,l}.$$

Horizontal tension

$$T=\frac{w\,l^2}{8\,S}.$$

WIND PRESSURE.

The figures for wind pressure exerted on outdoor station bus-bars follow generally those used for transmission lines erected in the same locality. Assumptions must be made for this pressure in order to determine the maximum loading on the buses. The assumptions, at best, are very approximate, for the wind pressure records are only taken at points. The pressures may vary greatly within a short distance, owing to the configuration of the ground and the height above ground level, and are thus only approximate for calculation purposes.

For the British Isles the speed of the highest recorded gust is about 110 miles per hour, whilst the mean velocity for one hour is 78 miles per hour. In general, it is found that (*a*) the wind velocities increase as the distance above ground surface increases; (*b*) the highest velocities do not occur in the cold weather simultaneously with an ice or sleet load; (*c*) wind velocities at the sea coast or on exposed high ground are higher than at points inland; (*d*) that structures cannot be built to withstand the velocity of tornadoes which may reach 200 miles per hour; and (*e*) velocities as a general rule rarely exceed 70 or 80 miles per hour.

The formula for the normal pressure in pounds per square foot of projected area is expressed by

$$p=K\,.\,V^2,$$

where K is a constant having a value between 0·0025 and 0·006; V is the velocity, either indicated or actual, in miles per hour. The limits for K mentioned here embrace all figures used in structural member design, and also for calculating pressures on cylindrical surfaces such as stranded conductors and tubes. With structural design the figure varies from 0·004 to 0·006, depending upon the shape of the members and the area exposed; but for cylindrical tubes or cables this is reduced by about 40 per cent.

From experiments at the National Physical Laboratory and Eiffel Tower a figure of 0·0032 has been obtained, and if V_i=the indicated velocity, the formula becomes

$$p=0{\cdot}0032\,.\,V_i^2.$$

The British regulations for overhead lines specify a wind pressure of 8·0 lb. per square foot of projected area for a cylindrical surface, this pressure giving an indicated velocity of 50 miles per hour. In America and Canada the corresponding formula is taken to be

$$p=0{\cdot}0025\,.\,V_a^2,$$

where V_a=the actual velocity in miles per hour.

Table IV gives the indicated and actual wind velocities and also the corresponding pressures for the two formulæ mentioned above. From this tabulation it is seen that the indicated velocities are higher than the actual, the difference increasing with increase of velocity. Generally, the wind pressure acting on the conductors is specified, but in cases where the velocity is given this can be substituted in the above formulæ to obtain the pressure.

The direction of the wind force is assumed to act horizontally in a plane at right angles to the bus-bars. In this case the calculated sag is not in a vertical direction, but at an angle inclined to the vertical.

TABLE IV.—*Relation Between Indicated and Actual Wind Velocities.*

Wind velocity in miles per hour.		Wind pressure *p*, lb. per square foot.	
Indicated by anemometer readings V_i.	Actual velocity V_a.	$0{\cdot}0032\,V_i^2$.	$0{\cdot}0025\,V_a^2$.
10	9·6	0·32	0·23
20	17·8	1·28	0·79
30	25·7	2·88	1·65
40	33·3	5·12	2·77
50	40·8	8·00	4·17
60	48·0	11·50	5·76
70	55·2	15·67	7·62
80	62·2	20·50	9·70
90	69·2	25·90	12·00
100	76·2	32·00	14·55
110	83·2	38·70	17·32
120	90·2	46·00	20·40

Although this assumption is usually made for sub-stations that are situated in very hilly districts it is quite possible for the structures and conductors to be subjected to wind gusts blowing almost vertically downwards.

With certain designs of outdoor stations the buses may be considerably shielded from the full blast of the wind by girders supporting apparatus. This shielding factor is a very unknown quantity and difficult to introduce into the calculations. The position of the conductors relative to the girders will affect the pressure, whilst the girders themselves vary greatly in design. The bus-bars are therefore assumed to take the full specified wind pressure.

(To be continued.)

The Mellor Refractories Research Laboratories.

ON Wednesday, December 5th, we were invited by the British Refractories Research Association to inspect its new headquarters, the Mellor Laboratories, at Shelton, Stoke-on-Trent. The laboratories have been fittingly named after Dr. J. W. Mellor, F.R.S., the Director, as a grateful recognition by the Council of his long and distinguished services to the ceramic industry. We reproduce below four typical laboratory views. The Association is the first independent institution to devote its activities solely to research and other cognate matters in the clay industry, and on its manufacturing and users' sides it has a very extensive field of operation before it.

It already has four joint committees carrying on special work. They are: The Refractory Materials Joint Committee of the Institution of Gas Engineers and the B.R.R.A., which deals with gas retorts, settings, &c.; the Blast-furnace Refractories Research Joint Committee of the British Iron and Steel Federation and the B.R.R.A., which deals with the use of refractories in blast-furnaces; the Saggar Research Joint Committee of the British Pottery Manufacturers' Federation and the B.R.R.A., dealing with saggars and oven refractories; the Open Hearth Refractories Joint Committee of the British Iron and Steel Federation and the B.R.R.A., which deals with refractories in the manufacture of steel.

It is very likely, we learn, that other important industries will see the necessity of combining their research programmes with the work of the laboratories.

THE MELLOR REFRACTORIES RESEARCH LABORATORIES

FIG. 1—SOME OF THE GAS FURNACES

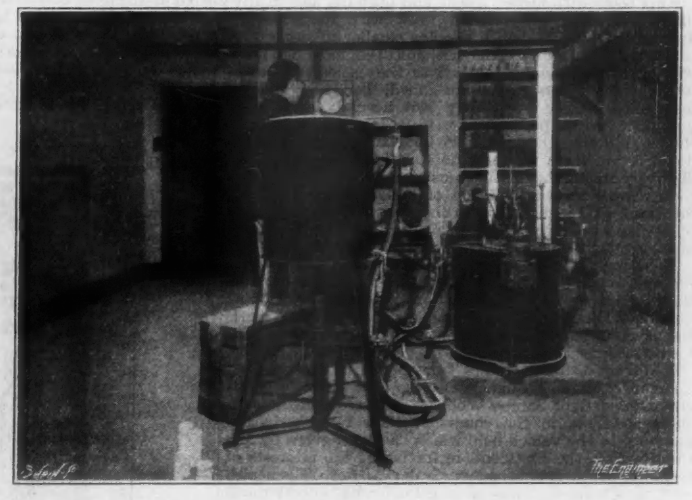


FIG. 2—SOME OF THE ELECTRIC FURNACES

FIG. 3—EXPERIMENTAL DRYER

FIG. 4—THE PETROLOGICAL LABORATORY

We may now refer very briefly to the history of refractories research in England. It was begun following a conversation between Lieut.-Colonel C. W. Thomas and Dr. Mellor, which had as its result a conference at the North Staffordshire Hotel on January 4th, 1909. The Conference was attended by representatives of the Institution of Gas Engineers and other industries, and shortly after that time, the Refractory Materials Committee of the Institution of Gas Engineers was formed, and research work was begun and advanced on a larger and larger scale. Following an interesting symposium on refractory material, held by the Faraday Society under the presidency of Sir Robert Hadfield in 1917, and the establishment a little before that time of the Department of Scientific and Industrial Research, the British Refractories Research Association was established on April 14th, 1920. From small beginnings work has continued to expand. From its inception the Chairman of its Council has been Lieut.-Colonel C. W. Thomas, who has been ably supported by his Vice-Chairman, Mr. F. West. The pioneer work of the Director, Dr. Mellor, who began testing refractories in the County Pottery Laboratory at Tunstall, and continued this work under D.S.I.R. grants at the North Stafford Technical College; and of Mr. A. T. Green, F.I.C., the Assistant Director, and the assistance given by Mr. H. Halliday, the Secretary of the B.R.R.A., call for mention.

THE NEW LABORATORIES.

The Mellor Laboratories, which are situated conveniently near the centre of the city, and are within easy reach of Stoke-on-Trent railway station, are contained in a building which was originally a private house and formerly a school, and which has ample room for future extensions. On the ground floor at the front are the offices, the Director's room, and the Board room, and at the rear two, one large and one small, testing laboratories. In the large room there is the 50 and 20-ton capacity Avery testing machine, and an impact tester, which have been suitably modified for refractory testing purposes. In the same room is apparatus for determining strengths and expansions of material at temperatures up to 1000 deg. Cent. The machine shown in Fig. 3 is an experimental dryer designed for drying large blocks of clay under constant conditions of temperature and humidity, and is equipped with an automatic weighing mechanism for recording the loss of weight of the clay under test. In the same laboratory there is an apparatus for the determination of the effect of carbon monoxide on refractory materials, and the disintegration caused by the breaking up of ferrous and ferric oxides present in the mass.

In this department work is also being done on the constitution of grogs, saggar materials, and the porosity and expansion of different saggar mixtures. By the addition of 10 per cent. of steatite a much longer life has been made possible. The smaller ground floor laboratory—see Fig. 2—is equipped with Hirsch electric furnaces, specially designed for testing refractories, and the expansion deformation characteristics of cements and refractory materials. Other rooms on the upper floors include the petrological laboratory for slag tests, shown in Fig. 4; a chemical laboratory, and a kiln-design department, equipped for varied work. The furnace-room is built at the back of the house and is shown in Fig. 1. It includes Brayshaw and Fletcher-Russell gas-fired furnaces for working up to 1500 deg. Cent., and a smaller furnace, which is used to study slag erosion. In an adjoining room grinding and workshop equipment has been installed. In addition to Dr. Mellor and Mr. Green, there are fourteen members of the research staff at Stoke and two at Sheffield.

After inspecting the laboratories, a luncheon was given at the North Stafford Hotel, and Lieut.-Colonel Thomas presided. In responding to the toast of "Our Guests," Sir Kenneth Lee, of the Department of Scientific and Industrial Research, congratulated the Association on its equipment and the work it was doing. He said that in 1932 he noted the Association was spending from £4000 to £5000 per annum on its work, but he reminded those present that no new Government-supported research association was now started which could not show an income of at least £10,000 for five years. He strongly recommended those interested in the heavy clay industries, both the makers, and the users such as the gas and iron and steel industries, to increase their support of the Association, so that its income would reach £10,000 to £12,000, a figure which, he said, would ensure even more thorough work and would bring definitely beneficial results to the industry. He congratulated Dr. Mellor on the formulation of such an effective and comprehensive programme of research, the need for which was unaltered and had already expanded.

SYMPOSIUM ON THE WELDING OF IRON AND STEEL.

AT the suggestion of the Department of Scientific and Industrial Research, and after careful consideration, the Council of the Iron and Steel Institute has decided to hold a Symposium on the Welding of Iron and Steel, to take place on Thursday and Friday, May 2nd and 3rd, 1935, in conjunction with the annual meeting of the Iron and Steel Institute, which will be begun on Wednesday, May 1st, 1935. The Symposium will be held in the Lecture Theatre of the Institution of Civil Engineers, Great George-street, Westminster. In view of the national importance of the subject the Council considered it essential that other societies and technical institutions directly concerned should be invited to co-operate. It accordingly approached the Councils of the following societies, with the result that their complete co-operation has been assured:—Institution of Automobile Engineers, British Iron and Steel Federation, British Steelwork Association, Institution of Civil Engineers, Institution of Electrical Engineers, Institution of Engineers and Shipbuilders in Scotland, Institute of Marine Engineers, Institution of Mechanical Engineers, Institution of Naval Architects, North-East Coast Institution of Engineers and Shipbuilders, South Wales Institute of Engineers, Institution of Structural Engineers, Institution of Welding Engineers. The general objects of the Symposium will be:—(*a*) To review the position of welding in all its industrial aspects, both in Great Britain and in other countries; (*b*) to obtain knowledge of the problems encountered in welding as employed by the various industries in Great Britain and in other countries; (*c*) to reveal what research work has been or is being undertaken and, arising out of the above, (*d*) to consider the advisability of taking steps to co-ordinate research work and to stimulate and guide future research, possibly with a view to formulating a national scheme. A detailed scheme of organisation and a list of papers to be invited has been prepared, and copies are available. A detailed programme will be issued at a later date. Mr. K. Headlam-Morley, Secretary of the Iron and Steel Institute, 28, Victoria-street, London, S.W.1, will be glad to supply further information about the Symposium, and also to receive suggestions, offers to contribute papers and applications to take part in the proceedings. The scheme of organisation which has been planned divides the Symposium into five groups as follows:—Group 1: Present-day Practice and Problems of Welding in the Engineering Industries; Group 2: Welding Practice and Technique; Group 3: The Metallurgy of Welding; Group 4: Specification, Inspection, Testing, and Safety Aspects of Welding; Group 5: Current Research Projects in Welding. In addition to papers from authors in Great Britain, it is hoped to obtain contributions from other countries.

INSTITUTION OF MECHANICAL ENGINEERS.

NORTH-WESTERN BRANCH.

THE annual dinner of the North-Western Branch of the Institution of Mechanical Engineers was held at the Engineers' Club, Manchester, on Thursday evening, December 6th. The chair was taken by Mr. Sterry B. Freeman, M.Eng., M.I. Mech. E., and over one hundred and twenty members and guests were present. After the loyal toast, "The King, the Duke of Lancaster," had been given by the Chairman and duly honoured, the toast of "The Institution of Mechanical Engineers" was ably proposed by Sir Frank Smith, F.R.S. In his speech Sir Frank referred to the great advance in mechanical engineering which had followed the discovery and utilisation of alloy steels. Reviewing the progress made in the last

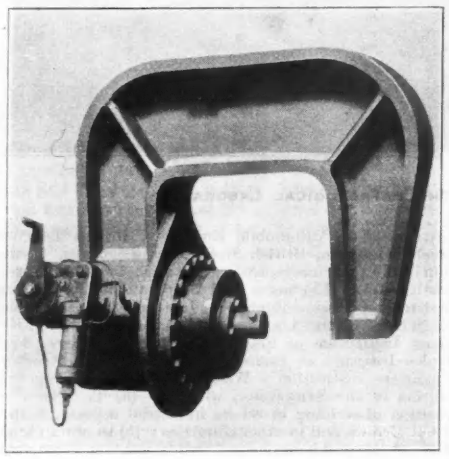
thirty-four years, he said that the four outstanding points of advance were the internal combustion engine, the use of the electric furnace, the discovery and application of alloy tool steels, including tungsten carbide and diamond cutting tools with higher speeds and outputs, and finally the introduction of precision work with its scientific methods of gauging, which enabled smaller tolerances to be used. By such means the mechanical engineer had contributed more valuable services to the nation than ever before. Each person, he continued, had now twelve mechanical slaves performing the normal services of pumping, electric power, and modern transport. Within the last 100 years the span of life had, on the average, been doubled and there was now no standing still. Scientific discovery and mechanical aid must go forward, or we should soon relapse into a condition of hunger and pestilence. Sir Frank paid high tribute to the work of the Institution of Mechanical Engineers and said that he counted many of its Presidents among his personal friends.

In his reply, the President, Mr. Charles Day, M.Sc. Tech., referred to the work of the Institution in Manchester and its districts, and to the formation of the Internal Combustion Engine Section. He also stressed the good work the Benevolent Fund was doing and made a strong plea for its increased support.

The toast of "Our Guests" was proposed in a pleasing manner by Mr. L. F. Massey, and the Lord Mayor of Manchester, Alderman Samuel Woollam, J.P., responded. Both these speakers, in the course of their remarks, made reference to the valued help which had been given by Mr. Charles Day, the President, in furthering the interests of technical education in the Manchester district. The health of "The Chairman" was proposed in a witty speech made by Professor G. E. Scholes, M.Sc., of Liverpool University, and Mr. Sterry B. Freeman briefly replied. The very enjoyable evening which was spent was made possible by the co-operation of the Branch Secretary, Mr. B. Y. Tams, with the officials and staff of the Engineers' Club.

An Electrically Welded Riveting Machine.

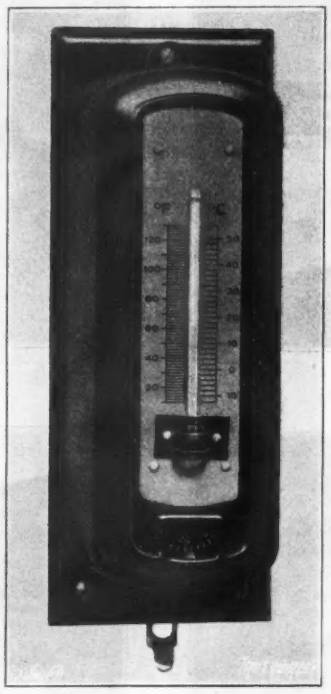
THE accompanying illustration shows a hydraulic riveting machine, constructed by Sir William Arrol and Co., Ltd., by electric welding. The web, flange plates, stiffeners and cylinders are all separate units, cut from mild steel plates and electrically welded together to form the structure. The gap of the machine is 18in. and the power which can be exerted by it is 50 tons. A special type of valve, to be seen on the left of the illustration, has been provided to give delayed action, and can be set in ten seconds. One of the advantages of this construction is, of course, that patterns are unnecessary and quick delivery can be given. With steel castings it is not uncommon to get blow-holes, and they may have to be rejected after a considerable amount of work has been done upon them. With a welded structure, on the other hand, there is no uncertainty in this respect, and another advantage is that the finished machine is lighter. Spring is also reduced to a minimum. When the machine was first constructed, it was found that the welding was stressed up to 20 tons per square inch, but the parts so affected were strengthened by ribs when the stress on the welding was reduced to 5 tons per square inch. We are indebted to *Electric Welding*, published by the Quasi-Arc Company, Ltd., for these particulars.



ELECTRICALLY WELDED RIVETING MACHINE

A New Thermostatic Switch.

A NEW thermostatic "room" switch, known as the Drayton Pilostat, has been introduced by the Drayton Regulator and Instrument Company, of West Drayton, Middlesex. It will operate within ±0·5 per cent. Fah., and will control any load up to 25 ampères A.C. or D.C. By reason of the fact that its operation is unaffected by angular deflections up to 20 deg., it is suitable for traction or marine work. A thermostat which only has to control a maximum of 5 watts is combined with a vertical mercury switch with an efficient magnetic circuit. The thermostatic element consists of a capsule containing a volatile liquid which responds rapidly with the slightest change of temperature. The capsule actuates the pilot switch direct without intermediate magnifying levers, and a magnetically controlled snap action is provided for the silver contacts. A pressed brass wall plate is fixed to a standard B.E.S.A. wall box, and three wires are connected to terminals at the back of the moulded Bakelite switch base, which carries the thermostat and relays. The bronzed cover cannot be removed by unauthorised persons. As shown in the illustration, a thermometer is fitted on the front of the cover, which also has a graduated setting scale, the setting temperature being indicated by a pointer formed integral with the cover, which need not be removed when connecting the switch to the load and mains. The switch is suitable for 100–120 volts D.C. and 220–250 volts A.C., 50 cycles, but for 220 volts and above a resistance is embodied in the relay coil circuit without adding to the dimensions. The makers explain that while several other thermostatic room switches are available, those that are capable of handling considerable loads direct will not operate within the small range of ±0·5 deg. Fah.



THERMOSTATIC SWITCH

LAUNCHES AND TRIAL TRIPS.

DAVID, steel motor tug; built by Arthur R. Brown and Co., Ltd., of Wivenhoe; to the order of the Crown Agents for the Colonies; dimensions, 42ft. 6in. by 10ft. by 6ft. Diesel engines of 5 L 2 type, cold-starting; constructed by Norris, Henty and Gardner, Ltd. Launch, December 1st.

RECULVER, STRATHEARN, motor tenders; built by Cammell Laird and Co., Ltd., to the order of the Corporation of Trinity House; dimensions, 173ft. by 33ft. by 15ft.; for lighthouse services. Diesel engines of the Atlas type; launch recently.

CRISPIN, single-screw steamer; built by Cammell, Laird and Co., Ltd.; to the order of the Booth Steamship Company, Ltd., Liverpool; dimensions, 405ft. by 55ft. 6in. by 36ft. 6in.; to carry cargo. Steam engines, triple-expansion reciprocating, with a Bauer Wach exhaust turbine, 24½in., 40½in., 67in., by 51in. stroke, pressure 220 lb. per square inch. Launch, December 7th.

CATALOGUES.

HOLDEN AND BROOKE, Ltd., Manchester, 12.—Lists on "Siflex" drive centrifugal pumps.

GENT AND CO., Ltd., Leicester.—Leaflet 222, dealing with synchronous clocks and Book 4D, with watchman's electric tell-tale clocks.

CHURCHILL MACHINE TOOL COMPANY, Ltd., Broadheath, near Manchester.—Publication 1062 dealing with the firm's hydraulic grinding wheel head.

BRITISH ROPEWAY ENGINEERING COMPANY, Ltd., 14–18, High Holborn, London, W.C.1.—Several catalogue sections of ropeway transporting plants.

SIMPLEX ELECTRIC COMPANY, Ltd., 159, Great Charles-street, Birmingham, 3.—Catalogue No. L 1419 of flameproof lighting equipment for collieries, factories, stores, &c.

PARSONS OIL ENGINE COMPANY, Ltd., Town Quay Works, Southampton.—Publication No. 131/1935, describing the M series engines supplied for petrol or kerosene fuel.

NATIONAL FEDERATION OF BRIDGE AND STRUCTURAL ENGINEERS.—At the annual general meeting of the National Federation of Bridge and Structural Engineers, held at Grosvenor House, Park-lane, Mr. E. A. Willson (Archibald D. Dawnay and Sons, Ltd.) was re-elected Chairman for the coming year, and Mr. W. T. Thornhill (Rubery, Owen and Co.), Vice-Chairman. The Executive Committee will consist of:—Mr. J. W. Baillie (Horseley Bridge and Thomas Piggott, Ltd.), Mr. R. Seymour Benson (Head, Wrightson and Co., Ltd.), Mr. T. Booth (John Booth and Sons (Bolton), Ltd.), Mr. H. Cunningham (Sir Wm. Arrol and Co., Ltd.), Mr. H. B. Denton (Joseph Parks and Son), Mr. J. R. Dixon (the Cleveland Bridge and Engineering Company, Ltd.), Mr. James Halliday (Francis Morton and Co., Ltd.), Mr. R. A. Hatfield (Burton Constructional Engineering Company, Ltd.), Mr. T. R. Miller (the Motherwell Bridge and Engineering Company, Ltd.), Mr. A. Robson (the Fairfield Shipbuilding and Engineering Company, Ltd.), Mr. J. C. Rome (John Lysaght, Ltd.), Mr. J. D. Stitt (Redpath, Brown and Co., Ltd.), Mr. Grahame H. Thomson (P. and W. McLellan, Ltd.), Mr. F. G. Woolley (Joseph Westwood and Co., Ltd.).

Water Supply in England.*

By ALAN E. L. CHORLTON, C.B.E., M.P.

WATER supply in this country has become one of the important public questions of the day.

The drought of this year and last has so intensified the situation as to force to the front some factors which would otherwise have lain dormant until with a continuing lack of attention quite serious results might have followed in the course of time.

Most of these factors are not new in themselves. They have been drawn attention to many times during the last fifty years in one way and another by Commissions and other bodies that have been set up to inquire into the general situation of the water supply of the country.

Since the time of the last Government Committee, other factors—as, for instance, that of the population, its probable decrease, its movement to other areas—have arisen, which have modified in some degree the recommendations made, sometimes increasing and sometimes reducing the value of the varying components which govern the question.

None the less, the question of our water policy is due for early settlement on a modern basis, the old *laisser faire* methods are out of date.

Communal water supply is a very old public utility; in fact, the oldest, as it is the basis of the good health of the community.

* * * *

During Victorian times individualism was exhibited strongly in all our doings, not only in regard to public supplies, but in industry, in the former perhaps to as great a degree as in the latter, and so much was the individualistic method the rule that all and any development which took place did so practically without any regard to the interests of parallel undertakings.

Even to-day in one and the same municipality there still exists no full co-ordination between the different departments, such as is now found in almost any industry. Thus the water department carried out its work quite distinctly and entirely separately from that of the gas or the cleansing or the drainage. Not only was there no co-ordination, but actual competition took place, particularly between gas and electricity.

The same disregard of the advantages of inter-working existed in the country as well as in the towns. Separate development of the various public utilities upon which we depend for our ordinary existence must have resulted not only in great loss of efficiency, but in the expenditure of much larger capital sums than would have been necessary had collective development, common planning and co-ordination taken place from the beginning.

The continuation of this separatist development since the war seems singular when compared with industry, where we have seen a general acceptance of the principle that many individual units of production or supply working separately cannot exist effectively under the changed conditions. They must adopt some form of co-ordinated working, preferably under a single control, in which the variety of the products they manufacture are allocated so that each factory makes but a single article or is limited to a small range of similar articles.

* * * *

To-day we seem to have arrived at a stage in which consideration of the subject can be divided into that of two groups of people. Those who consider it from a connected planning point of view, that of the water supply of the country as a whole, in which all the regional areas will be properly related as to supply, present and future, and in which each inhabitant shall have a normal share.

A question of such importance, they contend, demands that it should have special consideration on its own intrinsic merits. It bears such an intensely close relation to the healthy life of the community, and also to the carrying on and the development of industry.

No common supply of such importance can develop efficiently if it continues in the patchwork fashion in which it has so far grown up, and they hold that in this matter the estimation of all our water resources should be set on foot at once.

Whatever their limitations, it is probable that this group have a freer vision of what the future will require and a clearer eye of what is necessary to meet it than the others who are immersed in the daily carrying out of the duties of water supply.

In the second body are a number of able administrators and engineers who know from their own practice just how to carry on and meet the daily difficulties. They have not found it either necessary or within the scope of their work to consider the wider aspects of the situation, the collective working of a country-wide area of supply with the novel factors which must be taken into account if an efficient and widespread supply of this type were to be ultimately proceeded with. It might be disturbing in its effects.

On the other hand, very probably they are taking full note of all that is being so strongly advocated by the others, and making use of much of it without saying so—a very human precaution.

It appears to be their contention that co-ordination can be brought about by the regional committees that have been and are being set up.

So far, however, all these committees are advisory only. It is contended that existing committees have not been too successful because of the limitations.

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The late drought has forced forward a great many schemes for rural areas that have been affected all over the country which otherwise might have lagged for years.

The characteristic feature, however, of the earlier progress of water supply remains, namely, the persistence of the individual unit. It may be now for more than one village, but rarely so far for an area, although since the Act of 1929 which permitted parishes to incur expenditure exceeding twice their rateable value for water supply purposes, schemes for groups of parishes are becoming more common, and are, in fact, encouraged by the Ministry of Health and County Councils.

* Abstract of paper read at a Meeting of the Chartered Surveyors' Institution on December 10th.

The continuance of this feature, the lack of interconnection which might be not unreasonably effected in so many cases, is surprising. Apart from the advantage that arises from a pooling of supplies, such isolation prevents the adoption of a common reserve for the whole area.

No individual scheme can bear such reserve on its own costs, and the lack of interconnection prevents a common one being used. There are many country districts in which this may be noted, although in districts where the main source of supply is underground, the question of storage is not of such paramount importance, as it is already provided by Nature.

In the development of water supply as it is now, in these areas the first course is naturally to ascertain the potential sources for the whole of the district, whether they be flowing rivers, springs, or surface water generally. The strata is then investigated by inquiry from geological or other authorities, and the whole reduced to a comparative table of supply and cost.

The general desire of supply is to work by gravitational methods, which are borne in mind in making the lay-out of the piped system for each part of the whole area.

Many ingenious arrangements are now being adopted to bring into use water from all sources, and in certain cases where higher pressures are required in parts of a main system, mechanical devices of an automatic nature, like that of the hydrostat, are adopted.

Such methods of natural pumping are very economical. They can be used, however, only in certain circumstances. All this indicates the need for the accurate water survey of the district in which the supply is to be instituted or extended. In such a survey all sources must be taken into account. The site of an old mill may not only provide water from the stream, but the power by water wheel or hydrostat to force it to higher levels when it is required.

It is always the safest practice that schemes for water supply in country areas should be designed by expert engineers who are conversant with this class of work.

They do their best to work within the areas and the sources of supply available to them. What is lacking, as has been pointed out, is the common policy which shall enable all schemes to be co-ordinated and, as it were, helped out in their functions.

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What is to be the future policy of water supply of England? Are we to continue with that which has been the custom in the past or is something more on the lines of controlled planning from a centre to be instituted?

In many ways water supply has been one of the most conservative of our public utilities, and though no doubt within its limited sphere it has been carried out efficiently, it has never had a wide angle of view, nor even one taking much account of the future.

The present administration policy seems to be to attempt to overcome the disadvantages arising from the separate undertaking by setting up regional committees in which the various contiguous authorities can join. These regional committees cover both urban and country districts.

Unfortunately, these committees have not brought about joint action to the extent that was hoped for, mainly because they possess no executive powers. They are purely advisory, and their useful purpose of common action can be entirely set aside if vested and other interests are strong enough to block the way. So far nothing has emerged to indicate how this difficulty is to be overcome.

There is not much doubt, however, that the drought and the expression of public opinion arising from what it has revealed has stirred up those concerned, so that more effective inter-working may be expected.

A step forward beyond these regional bodies that has lately been taken is to set up joint committees covering still wider areas with the regional ones as sub-committees.

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The method of administrative development by main and sub-regional committees is interesting, for it would appear that by beginning with the individual undertaking by successive grouping we ultimately arrive at the central guiding authority that the advocates of the other school have pressed, for it is easy to see that when a number of large area provincial committees have been set up and begun to function, that the next logical step would be a combination of such bodies, through delegates, to form a central board.

The other proposal begins with the formation of a central board, but with statutory power. Whichever way connected action is secured matters very little. The crucial point is, Can success be attained by advisory means alone?

In the direction of the removal of legal limitations under which the statutory bodies have operated progress has been made. This can well continue if the Minister, having now such drastic powers as he has obtained under the new Act, though it is only an emergency one, so wills.

In connection with such limitations it might be suggested that the guidance of a central body, with statutory power to control policy and grant development by order, would, if nothing else, save a great deal of time and expense over the alternative system as now, which involves the necessity of a parliamentary inquiry or confirmation and Act before work can be undertaken.

There is also the general question of a common policy with other public utilities; a co-ordination to prevent overlapping and secure increased efficiency.

There does not seem to be any strong reason why drainage and water supply should not be properly interlinked and one used for the other where possible.

Electricity must bear relation to water in the sense that, where possible, pumping can be done at exceptionally low rates.

In another case, coke-oven gas might be used as the power supply for cheap pumping.

Another consideration, which is an important one, is that of population. From very careful analyses which have lately been published on the general tendency of population it was shown that in the comparatively near future there will cease to be any further increase to be followed by a decrease.

The policy of all local authorities in the development of their public utilities in the industrial districts in the North has been all along based on a continuing increase of population and trade. With a decrease there is bound to be considerable redundancy in some districts.

To overcome this, the aim should be to interlink the supply mains of various undertakings so that the supply in areas which become redundant will be available elsewhere.

Though this is the position in the North, it is not so in the London area. So much expansion, both in trade and population, seems to be indicated here that a long-visioned policy is called for. London has become even more the heart of the country in its activities, apart from being the seat of the Government.

The increasing population and vital industries, the immense public needs supplies, of which water is so important a one, are by no means invulnerable to air attack. This must not be lost sight of in any long-view policy.

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Will there be any development in the use of other water supplies as that of flood water from catchment drainage areas?

This combined working of catchmen drainage boards and water supply may become most important if it can be done effectively. An example is that of the new pumping station at St. Germans, near King's Lynn.

Some idea of the huge capacity of this station is obtained when it is realised that it is three times greater than the flow of the Thames this summer.

The question is, Can a plant of this type, similarly modified, be made to pump into a storage reservoir near by, or even to one in the Wash, to act as a reservoir for the whole district (though there are objections held against the latter situation from the risk of salt penetration)?

There are drainage works to be installed on the Trent. Can they be made use of for water supply? What appears to be a similar case is that of the Parrett in Somersetshire, where it may be possible to tap off the flood water in the higher reaches of the river to a reservoir to serve the whole country.

Any unsuitability of the water as it is now could be got over by chemical treatment. The use of storage reservoirs of this type for power production at times of peak load has been advocated. It is quite usual on the Continent, but it need not concern us here.

What will be the policy for reserve supplies? It is definitely suggested that such large reserves against prolonged drought when they come to be constructed must be common ones. There is not the water locally for each undertaking, nor can the capital cost be faced even if it were so in very many instances.

All this seems to confirm the desirability of the division of the country into large areas with a common storage reservoir for each area, and these must in their location bear relation to the proximity of the water supply available.

The Lake District and the Pennines have been mentioned as the special reservoir for the Lancashire West Riding industrial area, though the through connection to the latter has to be considered. A suitable line can, however, be found through Lunesdale to Wharfdale.

The interconnection of this latter area with that of Hull on the east coast was proposed by Mr. Newlands, of Bradford, by a main running cross-country, which, in effect, would be a continuation of that from Haweswater.

Central Wales is another district of high rainfall where a large national reserve should be set up. There is bound to be an increasing call from it in the future for London and the south-west.

How would the administration of such reserves be properly interlocked with that of all the other bodies concerned in supply from them? Could it be done by any form of regional joint council or must a central body be set up to control the whole?

Another reserve is that of the underground supplies. The general tendency of this supply is to fall, due to the increased number of bore-holes, &c., that have been put down. To overcome this it has been proposed and actually carried out to re-charge the underground water areas artificially from the surface with filtered water at times of river flood.

A little before 1890 Mr. Bryan, of the East London Water Company, poured filtered water into the chalk to raise the head against the risk of inflow of salt water from the Thames, and he succeeded in raising the water level, despite increased pumping. Such re-charging is done through so-called dumb wells.

This method of increasing underground storage has also been carried out in Germany at Hamburg, where it is stated the quantity drawn was increased from 21·38 per cent. in 1927–28 to 91 per cent. in 1933 of the total town supplies.

Even apart from any general survey it is most important that before this is carried out some law and order be brought in to regulate this important source of supply by making it compulsory to register and file particulars of all wells.

Another source of supply to act also as a transmission agent that has been suggested is that of the existing canals passing through the countryside. The variation of the surface level must, however, greatly limit their use as an aqueduct for this purpose, and their reserves in these cases are not so good.

This proposal has arisen mainly because some country districts have many miles of canals lying derelict, and could be taken over from their present owners at a relatively nominal cost.

As has been pointed out before, any difficulties arising as to the potability of the water can to-day be readily surmounted by the chemical processes available.

Small streams, of which there are many, fall under the same category. They may be used now, though usually for stock alone, perhaps because of ignorance or dislike of chemical treatment. Often where the fall is sufficient, as where in the past it has been used for a flour mill, it can by the use of a hydraulic pump be pumped to considerably higher levels.

In considering our general water policy of the future, there is no doubt the country districts will present the most difficult problem. The scattered population, the high cost per head, the low rateable value, still hold up development. It is said to be uneconomic, and because of this view there is still intense reluctance to face up to the real needs of the situation.

It cannot be considered unreasonable that every man, whether he lives in town or country, should have the opportunity of using a good supply of water. At the present time, if he lives in town he has it; if in the country, he probably has not.

It seems strange to many to provide him, as we have done, with electric light but not with water.

In many cases it would appear that the supply of some rural areas should be made more dependent upon the adjacent towns, and the responsibilities taken over by them.

With matters of policy of basic importance like those enumerated and many others, it is difficult to see how the present independent system is going to function and satisfactorily solve them. One is driven to a central body with some statutory powers. The central body should have statutory power to

(*a*) Make a general survey.
(*b*) Allocate to each province its fair share.
(*c*) Work out a general water policy for the country—taking into account all the relevant factors.
(*d*) Combine country districts with urban undertakings to form wide area provinces; release the limitations of statutory control to make this financially worth while.
(*e*) Interwork with other public utilities to prevent overlapping, redundancy, and to secure general national efficiency.
(*f*) Provide for general storage reserves like that of Central Wales.
(*g*) Lend money on favourable terms with Government guarantee to provinces or to undertakings.

The central body would not undertake any work itself, nor interfere with the management of town and country undertakings. It would be a directing authority with certain statutory powers.

South African Engineering Notes.

(By our South African Correspondent.)

Tide of Prosperity.

THE Union is now riding on the flowing tide of prosperity. The general revenue of the country will certainly exceed the estimate by two or three millions, while the railway returns are from £60,000 to £100,000 higher per week than the Administration's estimates. For the week ended October 13th the earnings amounted to £556,924, being the highest for the last five years and £98,000 above the Minister of Railway's estimated average weekly earnings for the financial year, which is £458,000. Up to October 13th the total earnings from April 1st were £14,073,200, against £12,356,767 for the corresponding period of 1933. On the monthly gold output of the Transvaal mines it seems almost certain that last year's total value of about £68,000,000 will be exceeded by several millions. Other industries are exceedingly busy. There is a boom in building. At Johannesburg the value of the buildings which will have been erected this year or are under construction will exceed £5,000,000, creating a big record, while Cape Town is also establishing a record with over £3,000,000. The new iron and steel works at Pretoria are so busy that the 1500 employees are to be raised to 2000 as soon as possible. The additional 500 men, mostly skilled, are being obtained from overseas; a portion will be employed at the new sheet works, which will be completed at the end of this year. There are great sums of money seeking investment, as shown by the fact that the municipality of Johannesburg invited subscriptions for a £2,000,000 loan at £98 10s., with interest at 3½ per cent., and in half-an-hour it was oversubscribed by £1,000,000 and Barclay's Bank telegraphed all its branches that the lists were closed. For the new gold mining ventures well over £20,000,000 has been subscribed in less than eighteen months and further new companies are finding it as easy as ever to obtain the capital they require. Much expansion has taken place in the demand for electricity, and in consequence new power stations and plants are being erected at various towns, while existing undertakings are having very considerable extensions undertaken, the latest big outlay announced being that of the Cape Town municipality, which has just sanctioned a programme to cost £435,000 for buildings, equipment, and distribution. In addition, the city will spend £270,000 on filtration plants for its water supply, £100,000 for new water mains, £220,000 for sewerage and storm water works, and £100,000 for sewage disposal works. Johannesburg is soon to order a 15,000-kW set and new boiler plant, to be in operation in 1936. Cape Town, in addition to the above new programme, has ordered and will install by May of 1935 a 20,000-kW generating set. Port Elizabeth (a 12,500-kW set), East London, Pretoria, Durban, Oudtshoom, Springs, Paarl, Prieska, Ceres, Eshowe, Salisbury (Southern Rhodesia), and other municipalities are also installing electricity undertakings or enlarging existing ones. But even greater developments in all directions are almost certain next year. The Electricity Supply Commission is raising a loan of £2,500,000. The issue price is £98 10s. and the rate of interest 3½ per cent; £2,200,000 of the new loan is to establish a new supply station at Klip, in the Vereeniging district of the Transvaal, which will have an initial power of 70,000 kW. Another new undertaking in the Witwatersrand district, extensions to existing undertakings and the cost of raising the loan, will absorb the remaining £300,000. Durban will be the centre of many electrical undertakings in the near future if schemes now being investigated by the Electricity Supply Commission are brought to fruition. According to Mr. John Roberts, local manager for the Electricity Supply Commission, and until recently, when he retired, electricity engineer to the city of Durban, demands for electricity are now arising from the sugar industry, seaside watering places on the South Coast, and from places along the main line to Cato Ridge. At present careful investigation is being made into the commercial side of the North Coast scheme for supplying the sugar industry, while on the South Coast there is a good prospect that, comparatively soon, supplies of electricity at prices comparable with those prevailing in Durban and suburbs will be available in a number of townships. In Southern Rhodesia Captain W. S. Senior, Minister of Mines, is dealing with the important question of a central electrical supply. Last year the Salisbury municipal electrical engineer investigated the feasibility of a central power station at Gatooma and

reported favourably. To probe further into the matter, Mr. A. C. Bagshawe, on his retirement from the service, was detailed to carry out investigations into other likely areas. He examined Gatooma, Queque, and Bindura and submitted a report which showed grounds for action on the lines of the Electric Supply Commission in the Union. It has been decided by the Cabinet that the matter shall be proceeded with, and Mr. Bagshawe is in Pretoria to find how Union legislation works. The matter will finally be dealt with by the new Parliament following the elections in Southern Rhodesia.

Production at Pretoria Steel Works.

The Pretoria works of the South African Iron and Steel Industrial Corporation are now in full swing and the rolled steel sections produced there are already being used in important structural engineering works in the country. I am advised that the works have just completed an order for 1000 tons of structural steel sections for the Railway Administration. This material will be used in the construction of 500 railway wagons which the railways are building in their own workshops. A considerable tonnage of other iron and steel products has been delivered to the Railway Administration. Steel girders for the framework of the many skyscrapers now being built, and steel rods for the reinforced concrete used in them, are being made from "Iscor" steel at the rate of about 2000 tons a month. The works are also supplying steel for the new electric generating station now being built at Klip River for the Electricity Supply Commission, as well as for the extension of the Pretoria municipal power station. The Vereeniging works of Messrs. Stewarts and Lloyds are taking a thousand tons a month of "Iscor" steel. This is in the form of small blocks weighing from 150 lb. to 300 lb., and is required to be a special quality, as the steel blocks are to be drawn out into seamless steel pipes. Small rails for cocopans, larger rails for the underground electric locomotives on the Rand, gold mines and main line rails for the Railway Administration and mine sidings are now regular products of the works. Pig iron is supplied for the large number of foundries on the Rand and in Pretoria. There is a constant demand for this and the dispatches from Iscor works aggregate over 1000 tons a month. It is regarded as only a matter of time before the distribution of the works products, almost daily increasing in variety and quantity, will reach all spheres of industrial activity in South Africa.

A Harbours Advisory Engineer Appointed.

Mr. John F. Craig, Harbour Engineer of Table Bay, has been appointed Harbour Advisory Engineer to the Union Government to control all harbours on the 1800 miles of coast line from Swakopmund to Durban. This appointment is the resuscitation of a post which has been vacant for about ten years and is a fitting reward for an engineer who has been instrumental in saving the Union Government £9,000,000 on one undertaking alone. Mr. Craig came to Cape Town two years ago from Port Elizabeth, where, as Harbour Engineer, he undertook the construction of the new harbour, which can now shelter large mail steamers. A scheme costing £12,000,000 had been drawn up on plans evolved during the past sixty-five years. The first harbour surveyors had decided that it would be impracticable to build a big harbour on the existing site of the Algoa Bay docks, as the submarine floor consisted of solid rock. Experts who worked on the scheme all followed the original theory that it would be necessary to build the harbour further north along the beach towards the mouth of the Swartkops River. Owing to the exposed position and the necessity for great breakwaters, the plan was estimated to cost £12,000,000. As Harbour Engineer, Mr. Craig actually started to build a breakwater, but after running it out for 400ft. he decided to investigate for himself the bottom of the existing harbour and its surroundings. He then discovered that instead of being solid rock it was sandstone, and that with modern dredgers it would be possible to clear this sandstone away. The Algoa Bay harbour scheme was thereupon revised and Mr. Craig's final plans provided for a harbour in every way adequate to any possible development of the trade of the port during the next half century or more, for the harbour works, including the south and north breakwaters, enclose an area of fully 250 acres. This scheme has now been completed at a cost of only £3,000,000, including a sufficient provision of quays and equipment to meet a considerable expansion of the present demands on the port, and with ample room for the provision of more quays, &c., as the trade of the port may call for such additions. Before being appointed to Port Elizabeth Mr. Craig occupied the position of Harbour Engineer at East London for six years, and while there drew up the scheme for the turning basin at that port, which is enabling large liners to dock in the Buffalo River. Mr. Craig is forty-nine years old and a South African by birth. He was educated at St. Andrew's College, Grahamstown, and Rhodes University College. He took his civil engineering training at Trinity College, Dublin.

New Fast Mail and Intermediate Ships.

As part of a £5,000,000 modernisation scheme to meet foreign competition, the Union-Castle Company is shortly ordering four fast motor passenger liners for the South African trade. Tenders have already been called for. Two of the new vessels will be for the intermediate service of the Union-Castle Line, and two for the Bullard King Natal Line, which is run by the Union-Castle Company as a separate concern. These four ships will cost more than £2,000,000 and form the second instalment of the Union-Castle Company's extensive replacement programme, begun with the ordering this year of two 25,000-ton mail liners and two 7000-ton fruit ships, at a total cost of £3,000,000. Two of the ships at present in the mail service, "Kenilworth Castle" and "Armadale Castle," will be replaced by the two 25,000-ton motor liners, which will be twice their size and several knots faster. The "Durham Castle" and "Dunluce Castle" at present running as intermediates, will be replaced by the two new motor vessels for the intermediate services. These will be improved "Llangibby Castles," larger and faster than any ship now engaged in the intermediate service or, in fact, than any ships circling Africa. Their exact size is not yet known, but they will be over 12,000 tons gross and have a speed in excess of 16 knots. The ships for which tenders have now been called for will take from eighteen months to two years to build and will probably go into service about the middle of 1936. Of the four ships already under construction, the two refrigerated fruit ships will be the first completed and are expected to be put in service in time for the beginning of the next deciduous fruit season, about April next year. The 25,000-ton mail liners will both be completed at the beginning of 1936. They are to be faster than any ships at present in service between England and South Africa. There is no doubt that speed is assuming greater importance in the South African trade, and ships that have not the speed are left out in the cold. That is why although the vessels at present engaged in the Union-Castle Line service are all in excellent condition and good for many years' service yet, the company has decided to replace some of the older boats with new ships which will be the fastest and largest on their respective routes.

Ermelo Torbanite Deposits.

The torbanite deposits of the Union are again receiving attention, and it certainly appears this time that something definite will result. At the first annual meeting of the Nigel Transvaal Consolidated Investment Company, held recently, the chairman in the course of his speech said that one of the new enterprises in which the company would become interested was the administration in South Africa of a new company in course of formation to erect the first refinery for crude oil in the Union and simultaneously to open up extensive torbanite deposits in the Ermelo District of the Transvaal. In this oil venture the company is working with important interests in London, namely, the British Burmah Petroleum Company, Ltd., and John Taylor and Sons. The company is to be called the South African Torbanite Mining and Refinery Company, Ltd. The company will erect and operate retorts for the extraction of crude oil from these Ermelo deposits, while the refinery for the production of petrol and other oil products will be erected in the neighbourhood of Johannesburg. The capital of £750,000, divided into 1,500,000 shares of 10s. each, has been underwritten by the Anglo Transvaal Consolidated Investment Company, Ltd., and the British Burmah Petroleum Company, Ltd. The South African torbanites do not contain sufficient nitrogen to make the production of sulphate of ammonia of commercial importance. But when suitably treated, they give a yield of oil from three to six times that obtained in Scotland and from some torbanites the quality of oil is almost indistinguishable from high-grade crude petroleum. Consignments of torbanite were sent overseas and were treated by alternative methods in England and America, so as to produce sufficient volumes for practical tests. The quality of the motor spirit thus made was reported to be exceptionally good. An interesting by-product of the retorting of the Ermelo torbanite is known as "bottled gas" and may be of great importance to South Africa.

New Harbour Tugs.

The first of the new tugs built on the Clyde for the South African Railways and Harbours Administration, the "John Dock," has arrived here. The second tug, the "W. H. Fuller," will follow shortly. The "John Dock" will be stationed at Port Elizabeth and the "W. H. Fuller" at East London. The "John Dock" is very similar to the Cape Town tug "T. S. McEwen." She has a single fat funnel and two pole masts. Being 15ft. shorter than the Cape Town vessel, having a length of 145ft., the bridge deck has been shortened correspondingly, and the chart room, wireless cabin, and enclosed wheel room surmounted by an open bridge, are more compactly arranged. The "John Dock" and the "W. H. Fuller" were constructed at Govan by Harland and Wolff, Ltd. On trials on the Skelmorlie measured mile a speed of 14 knots was attained. There are only two more powerful tugs on the South African coast, the "T. S. McEwen," with engines of 2800 h.p., and the Durban tug, "Sir William Hoy," with engines of 3500 h.p. The new ships have engines developing 2600 h.p. The propelling machinery consists of two sets of triple-expansion steam engines. Steam is generated in four water-tube boilers, coal being used instead of oil fuel, as it is more easily obtained at South African ports.

Junkers Planes Find Favour.

Thanks to the apathy of British manufacturers of aeroplanes, it will surprise no one if in a couple of years their planes are entirely discarded from use by the South African Airways (once a private concern, now taken over by the Union Government). At the commencement the company had not much capital and so approached the British firms to try and get accommodation which, as is generally the case with British firms, was refused. The company at length sought aid abroad, and Junkers eagerly embraced such a splendid opportunity for breaking the British monopoly of a branch of transport possessing a future, the development of which one cannot as yet estimate, except to the extent that it is bound to be magnificent. A further step has now been gained by Junkers, to whom a draft for £71,000 was cabled by the Union Government (per S A. Airways) on November 9th. This amount represents payment for three new Junkers air liners, which arrived during the week and passed all tests. These planes are seventeen-seaters (there is not a British plane in South African service that carries more than five), and are equal to the plane which came second in the recent Australia air race—without any mishap. With a working speed of 150–170 miles per hour they are said to be able to touch 200. Another new Junker plane, which is being brought out from Germany to replace one that crashed some time back, will arrive early next year. It is a seven-seater machine of the very latest type with a cruising speed of just on 200 miles an hour, and will bring Durban within 1½ hours of Johannesburg. It may be added that the Minister of Defence stated the other day that the present Defence Force air machines (British) were flying satisfactorily at 150 miles per hour, but much higher speeds would soon be required. British manufacturers supplying the Union Government Defence Department and those supplying the Union with passenger carrying machines must look to their laurels or they may find that they have lost the Union market altogether, thanks to the enterprise of the German firm.

Harbour Commission's Survey Completed.

The Harbours Commission, consisting of Mr. Gerhard Nijhoff, a Dutch engineer, and Mr. C. C. Geertsema, his assistant, have completed their survey of the Union harbours and are now at Johannesburg completing the preparation of their report for the Government. Mr. G. P. Nijhoff had undertaken for a fee of £1000 to investigate the beach erosion problem for the Durban Town Council, but has now notified the Council that he cannot carry out the work, circumstances having arisen which makes it impossible for him to spare the time. It appears that Mr. Nijhoff has received an unexpected call from the League of Nations, to which he is attached as an expert on technical matters, to undertake important work in China, including investigations into the methods of regulating the Yangtse Kiang River.

Pretoria to Scrap its Trams.

The City Council of Pretoria has agreed to the scrapping of its tramway system, and to the substitution of heavy oil omnibuses. The Council has decided to start with sixteen omnibuses, ten single-deckers and six double-deckers. Tenders have already been submitted, ranging from £19,110 to £30,074. The lowest is Stinnes (S.A.), Ltd. (Bussing); and Leyland Motors is next with £20,080. Whether the difference of £970 will give the German firm the contract remains to be seen.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

MR. WINTON THORPE has entered into a working association with Waldo, Maitland and Partners.

THE WESSEX ENGINEERING COMPANY, Ltd., has opened larger premises at Sipson, Middlesex.

MR. CLEM PARKER, late of Bennis and Co., Ltd., of Bolton, has jointed the London staff of Davey, Paxman and Co., Ltd., of Colchester.

MERZ AND MCLELLAN have to announce that Mr. William McLellan is retiring from partnership in the firm on December 31st, 1934.

ALFRED HERBERT, Ltd., request us to say, regarding the conflicting notices about the Telsen Electric Company, Ltd., that they have purchased the assets from the receivers and have, in turn, sold the goodwill, stock-in-trade, and trade name to David Rosenfield, Ltd., of Manchester, who will continue the Telsen business. Alfred Herbert, Ltd., are in no way interested in the manufacture of wireless components.

AMOS AND SMITH, Ltd., Albert Dock Works, Hull, have acquired as a going concern the business of Hull Central Dry Dock and Engineering Works, Ltd., Humber-street, and take possession on January 1st next. The purchase includes a private dry dock, 340ft. by 51ft., entered from the river Humber at the mouth of the river Hull, with adjoining engineering and ship-repairing works, well equipped with modern plant and appliances. The name of "Hull Central Dry Dock and Engineering Works" is to be retained, with a portion of the present staff.

CONTRACTS AND ORDERS.

The Editor is always happy to print short announcements of contracts and orders in this column provided they are sent to him in time to have news value and that they are likely to interest readers.

PARSONS OIL ENGINE COMPANY, Ltd., has received from Harland and Wolff, Ltd., the order for a 10-kW kerosene emergency generating set, with Laurence Scott dynamo for the new Elder Dempster vessel they are building. Parsons Oil Engine Company, Ltd., is also supplying to Messrs. Rowhedge two standard kerosene engines for police launches building at that yard, and for Merryweather, Ltd., a 110 h.p. petrol engine with reducing gear, for a fire float.

HICK, HARGREAVES AND CO., Ltd., have recently secured contracts for a 50-000-kW surface condensing plant with auxiliaries and closed feed system for the Ironbridge generating station of the West Midland Joint Electricity Authority; a 30,000-kW surface condensing plant for the Northampton Electric Light and Power Company, Ltd.; and a large central evaporating plant for the Klip power station of the Victoria Falls and Transvaal Power Company.

JOURNAL OF APPLIED MECHANICS.—The Applied Mechanics Division of the American Society of Mechanical Engineers, beginning in March, 1935, will publish a "Journal of Applied Mechanics." It will appear four times each year in issues containing about 80 pages each. Emphasis will be laid on the industrial applications of research.

"ONE HUNDRED YEARS."—Under the title "One Hundred Years," George Cohen, Sons and Co., Ltd., have just issued a very handsomely produced and copiously illustrated centenary volume. The firm was established in a very humble way in Goulston-street, a turning off Aldgate, in 1834, and its trade appears to have consisted in the purchase and sale of cast and wrought iron scrap. Of steel scrap in those early days there was little or none. The founder was bucolic in appearance, and was known amongst his friends as Farmer George. "He was a cheerful, kindly, big-hearted man, and everywhere made friends who held him in affectionate regard," and "it is scarcely an exaggeration to say that he was adored by his workmen." The firm progressed slowly in the face of grave difficulties, but in 1869 the original premises were found to be too small. In that year a large depôt with offices in Cable-street, St. Georges, was rented. A little later another depôt was opened in Canning Town, and the firm began to trade in machinery as well as scrap. By 1876 further development was necessary, and a move was made from Cable-street to 600, Commercial-road, where the head offices of the company still exist. In 1890 the founder died, and Lewis Levy, one of his sons-in-law, took command. To him is due the development of the ship-breaking business. He died in 1913, and was succeeded by his son, Lawrence, who is the present chairman. Under him the company has greatly extended its interests, and now has a controlling interest in many other companies, all of which hold important positions in the engineering industries. To each of these associated companies some pages of the volume are devoted. A notable feature of the book is the attention which is paid to the staff and *personnel* of the head and other companies.

Markets, Notes and News.

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer. A comprehensive list of the prices of materials mentioned below will be found on the next page.

Steel Trade Discussions.

The meetings which took place last week between the British steel makers and the representatives of the European Steel Cartel in London were not productive of results of any consequence. As this was the first occasion upon which the Federation had been officially engaged in negotiation with the Cartel it was not expected that anything more than a discussion upon the outstanding difficulties between the two industries would take place. As we have explained on other occasions in these columns, the Continent would like a much larger share in the British market than the British steel makers are inclined to give. It is likely that in the export market a price arrangement would be possible. No doubt the negotiations will go on, but it will probably be some time before anything very definite emerges from these international discussions. In the meantime, the steel makers and the structural engineers have at length reached agreement upon several questions of a troublesome character. It is understood that an attempt has been made to settle the problem presented by those structural steel concerns which are associated with the steel makers, and which for years past have been able to take the greater part of the constructional steel business coming on the market in this country. The members of the structural steel industry are also discussing between themselves a scheme of quotas, and schedules have been agreed upon regarding prices for complete structures of various descriptions. The recent revised list of extras which was issued by the British steel makers contained no surprises and differed in only a few minor details from the old list. It is reported, however, that a new sheet extras list is under discussion which may bring ¼in. sheets under control. This has been talked about for some time, and hitherto it has not been possible to reach an agreement.

The Pig Iron Market.

The decline in the volume of business which usually occurs in December has affected all departments of the iron and steel markets; but it is less noticeable in pig iron than in other branches. The current demand is confined principally to small tonnages for near delivery, but renewals of contracts which expire at the end of the year are being negotiated. In some cases consumers are not taking so much iron under the new contracts as under those which have been worked off. Although the situation on the North-East Coast remains satisfactory, there has been a distinct fall in new business. This may be partly accounted for by a slackening in the day-to-day demand from the Scottish foundries. On the other hand, specifications from users in the Glasgow and Falkirk districts who have running contracts with East Coast producers are coming forward steadily. Business with local consumers of Cleveland iron is on a good scale and has shown none of the usual seasonal signs of weakness. The makers do not seek export orders, as the prices they have to take are not attractive; but a certain amount of overseas business is transacted weekly, generally with old customers. The Midland iron market has been less active during the past ten days than at any time this autumn. The decline in demand is chiefly noticeable in the light castings section, and it is assumed that there is not likely to be much improvement in the call for pig iron from this industry until it begins to feel the usual spring revival in the demand for builders' castings. Some compensation is afforded, however, by the increase in the quantities of pig iron taken by the engineering industries. A slight expansion in the request for forge iron was short lived and comparatively little of this material is passing into consumption. In Scotland the volume of business shows little change from week to week. This month the ironmasters have had little to complain about, as there has been a good number of contract renewals which will enable them to enter the New Year with satisfactory order books. In Lancashire also trading conditions are favourable. Scrap prices, however, are not high and as a result large quantities are being used by the foundries to the detriment of business in pig iron.

Scotland and the North.

Whilst the market for finished steel materials in Scotland has been less active than during the latter part of November, there has been no decline in the rate of production. The industry as a whole will finish the year in a good position, and early in 1935 should reap the benefit of the shipbuilding orders recently placed with the Clyde and Belfast yards. A considerable tonnage of shipbuilding steel is being produced, and specifications from other consuming industries are reaching the steel works regularly. The heavy engineering industry is busy in several departments, and is taking good deliveries of steel. Most of the structural engineering firms are well employed, and provide a good outlet for sections and joists. The position of the works producing railway material has been improved by the receipt of new contracts, some from the home railways and others from abroad. One Scottish firm has secured a good order from the Indian State Railways for rolling stock. The sheet works in Scotland have a good tonnage of orders in hand. Most of this, however, is for home consumers, and this month the demand has fallen off slightly. The industry, however, is operating at slightly below 50 per cent. of capacity, and it anticipates a seasonal improvement in export business in the New Year. The situation in Lancashire gives little cause for complaint. Current business has declined a little, but deliveries against contracts are being maintained. The demand for the lighter steel materials keeps up well, and most of the re-rolling firms are meeting with a satisfactory request. Lately the requirements of the machinery makers have increased as a result of some useful contracts which have been placed in this district. Business in alloy steels has been maintained, and for the moment seems one of the steadiest departments of the market. The plate makers are not busy, and business in boiler plates since they were brought under control has been insignificant. This, however, may be due to consumers having anticipated their forward requirements in expectation of the advance. Barrow works are assured of entering the New Year with good order books as a result of some recent contracts. Amongst these is an order for 1000 tons of rails and 20,000 tons of sleepers for Brazil. Home railways are also specifying fair tonnages for 1935 delivery. A moderate tonnage of shipbuilding steel is going into consumption on this coast.

The Midlands and South Wales.

Whilst individual works in the Midlands may have some cause of complaint at the trend of business during the past few weeks, the general position remains satisfactory. The demand for structural steel has become a little less active, but as most of the constructional engineering firms have substantial contracts in hand it is assumed that this is only a temporary lull. The demand may also have been affected by the negotiations that have been proceeding between the constructional firms and the steel makers on questions that have been outstanding between the two branches for a long time. There is often a tendency in such circumstances to hold up business in case trading conditions may be affected. The plate makers are not so well placed as most other sections of the industry, and some of the mills are working irregularly. Since boiler plates were brought under control the demand has been almost negligible. Business in sheets has been on a good scale so far as home consumers are concerned, but the recent burst of activity on the export side of the market has not been maintained. Generally speaking, however, the sheet mills are fairly busy and are likely to remain so for the next few weeks. The position in the small bar trade has not altered. The volume of business is satisfactory, but competition is keen and lately sellers of Continental merchant bars have booked a good tonnage of orders. The associated works, also, continue to lose business to those makers who do not recognise control. Recently there has been a revival in the demand for bright-drawn steel bars, but here again the quotation of the associated makers of £13 10s. for rounds is not competitive with those of the outside works. One of the bright features of the market is the activity in the colliery steel section. The works producing this material have well-filled order books. The industry in South Wales is rather less busy than a few weeks ago, but this is causing no anxiety. The quieter conditions are chiefly noticeable in the tin-plate market, the export demand having declined lately. On the other hand, there are some substantial home trade inquiries in circulation. Business in sheet and tin-plate bars has reflected the conditions in the tin-plate industry. The constructional engineers, however, are busy and are taking good quantities of structural steel.

Current Business.

Wm. Baird and Co.'s scheme for reconstructing their blast-furnace plant at Coatbridge at a cost of £500,000 is to be revived. It is stated that the scheme is regarded as essential to the future of the iron and steel industry in Lanarkshire. Sir Arthur Rose, the Distress Area Commissioner for Scotland, hopes to ensure a market for the surplus gas. An order for a timber and coal-carrying steamer of 2850 tons deadweight has been placed by Glen and Co., of Glasgow. The triple-expansion engines will be built by David Rowan and Co., of Glasgow. Fraser and Chalmers Engineering Works of the General Electric Company, Ltd., Erith, Kent, have secured a contract from the Chinese State Railways for a complete power station, a coal storage reclaiming and shipping plant, and handling equipment for general merchandise. The contract has been given out in connection with the development of a new port in Honan. The Motherwell Bridge and Engineering Company, Ltd., have secured a contract for fifty steel bridges from the Chinese Purchasing Commission in addition to contracts for sixteen bridges already in hand. The latest order will involve the use of about 2000 tons of steel. At a meeting of the Management Committee of the Wolverhampton Industrial Development Association, the Development Officer (Mr. Arnold Heckle) said that there had been an abnormal demand for factory accommodation during the past twelve months. A number of firms, finding their factories inadequate to deal with the work in hand, had been forced to expand or remove into new premises. With one exception there were no empty factories now available in Wolverhampton suitable for the requirements of modern industry. New industries which had been attracted to the town during the past few years were employing 7000 people. The Department of Overseas Trade reports that the following contracts are open for tender:—Montevideo, National Fuel Administration: twenty-eight steel tanks, various dimensions, and accessories for a petroleum refinery (Uruguay, January 8th); Toronto, Department of Works: centrifugal sewage pump, 2,000,000 Imperial gallons capacity, motor and accessories (Toronto, January 8th); Indian Stores Department: supply and erection of oil engine-driven generating sets, air compressing and cooling plants (New Delhi, January 14th); 259 inter-vehicle five-point couplers (New Delhi, January 3rd); Egyptian Ministry of Public Works: two electric centrifugal pumping units for the Esna Barrage (Cairo, January 16th); twelve similar units and accessories (Cairo, January 12th); Argentine State Railways Administration: air compressors, pneumatic and machine tools, &c. (Buenos Aires, January 16th).

Low Temperature Carbonisation.

The report of Low Temperature Carbonisation Ltd., for the financial year ended October 31st, 1934, is more than usually interesting, since it deals at some length with the successful record of Coalite smokeless fuel. The financial position of the company appears sound and after allowing for interest and other charges a dividend of 3 per cent. less tax is paid on the ordinary shares. The sales of Coalite smokeless fuel, Coalite petrol, Coalite oil and sundry revenue totalled £328,189, an increase on last year of £53,760. It is pointed out that the sales of Coalite this winter up to October 31st were 20 per cent. greater than those of the corresponding period of last year, and that the company is unable to cope with the volume of orders available. It is claimed that the company's total output constitutes about 99 per cent. of the fuel made by low temperature carbonisation processes working throughout the country. Reference is made to the scheme announced at the annual meeting last year for erecting two further plants, and it is now stated that before proceeding with the erection of the works it was necessary to secure an amendment to the scheme under which the Coal Mines Act is administered in South Yorkshire. The company, therefore, in January, made an application to the Investigation Committee set up under the Act and the case was heard in February. In March the Committee representing five different classes of interests announced that they had unanimously decided in the national interest to grant a special quota for all coals required for low temperature carbonisation. This decision was followed by prolonged negotiations with the different districts, and it was not until October that the new scheme, which comes into force on January 1st, was passed. Under the new arrangement all coal required for existing and future works will be provided on a special quota. This will place the company in a much better position for ensuring sufficient and regular supplies of the coal required.

Copper and Tin.

A more confident tone has developed in the copper market as a result of reports that the discussions between the copper producers regarding a curtailment of production have resulted in a plan being drafted, which will be considered at a meeting in New York early in January. According to reports a real effort has been made to overcome the reluctance of some of the African producers to enter a scheme, and it is understood that the attitude of the Belgian group is much more favourable than was recently the case. The position of the Canadian copper producers which provided a problem seems likely to be met by the formation of a pool of other copper producers, which would purchase the Canadian metal at a fixed price and arrange for its marketing. Some scheme of this nature is necessary in any scheme of world restriction of output since Canadian copper is mined with nickel and gold. Lately the British consumers have shown a greater interest in the market than for some time, and Italian users have also bought moderate quantities. In the standard copper market speculation has been more active and at the moment there is a fair-sized bull account open. Occasionally the speculative demand has been met by free selling, it is assumed, by American producers. . . . In spite of the improved position of the metal, as shown by the November statistics, there has been little movement in the tin market. American buying has expanded and the market, as usually happens when American users buy on a fair scale, has taken the view that consumers there are short of the metal. The Continental demand has been quiet and the financial conditions in most European countries are against any active buying of tin. An nteresting development is that Italy has commenced smelting tin ore from Spain, which until recently was sent to Germany for treatment. In Italy there is an import duty of 15 per cent. upon tin, whilst ore is admitted free. It is reported from Holland that the Commission which has been investigating the proposed amalgamation of the Banca and Billiton mines will report early in January. It is suggested that the idea is to strengthen the Dutch tin undertakings in the international discussions.

Lead and Spelter.

Conditions in the lead market scarcely vary from week to week. Price fluctuations have been too insignificant to arouse any interest, but, on the other hand, there has been a substantial demand from the consuming trades. The manufacturers of pipes and sheets continue to take good deliveries of pig lead, whilst the requirements of the battery makers and the manufacturers of bearing metals have grown appreciably of late. The chief feature of the market still is the scarcity of Empire metal. Recently there has been a brisk demand for prompt lead, and duty-free metal has been taken out of warehouse at a premium of 25s. The stocks of duty-free metal are not large and it seems possible that the premiums will tend to increase. The statistical position of the metal seems likely to improve. For one reason Japanese imports in August and September considerably increased as a result of the work necessary to repair the ravages of the tornado in that country. . . . Little of interest has developed in the spelter market of late. Some of the Continental producers who until recently sent their metal into Germany have now to find another market, and as a result larger quantities have been sent to this country. The impression still prevails that the Cartel will be dissolved at the end of the year, but beyond creating a rather pessimistic feeling in the market this has had little influence upon conditions here. It is evidently felt that even a period of unrestricted competition is not likely to bring prices much lower than they are at present. The American statistics show that the stocks at the end of November had increased by 5049 tons to 116,076 tons. This is the highest level reached this year.

Current Prices for Metals and Fuels.

Makers' official home trade prices, per ton, delivered buyers' stations. Sections, joists and plates are subject to a rebate to home users purchasing only from associated British Steelmakers: joists, 22s. 6d.: plates and sections, 15s. Export orders of 250 tons and over may be subject to special quotations.

PIG IRON.

	Home. (*D/d Teesside Area*)	Export.
N.E. COAST—	£ s. d.	£ s. d.
Hematite Mixed Nos.	3 8 6	3 0 0
No. 1	3 9 0	3 1 0
Cleveland— (*D/d Teesside Area*)		
No. 1	3 10 0	3 4 0
No. 3 G.M.B.	3 7 6	3 1 6
No. 4 Forge	3 6 6	3 0 6
Basic (*Less 5/– rebate*)	3 7 6	—
MIDLANDS—		
Staffs.— (*Delivered to Black Country Station*)		
North Staffs. Foundry	3 11 0	—
„ „ Forge	3 6 6	—
Basic (*Less 5/– rebate*)	3 12 6	—
Northampton—		
Foundry No. 3	3 7 6	—
Forge	3 2 6	—
Derbyshire—		
No. 3 Foundry	3 11 0	—
Forge	3 6 0	—
SCOTLAND—		
Hematite, f.o.t. furnaces	3 11 0	—
No. 1 Foundry, ditto	3 12 6	—
No. 3 Foundry, ditto	3 10 0	—
Basic, d/d (*Less 5/– rebate*)	3 7 6	—
N.W. COAST—		
Hematite Mixed Nos.	3 12 6 d/d Glasgow 4 0 6 „ Sheffield 4 5 6 „ Birmingham	

MANUFACTURED IRON.

	Home.	Export.
LANCS.—	£ s. d.	£ s. d.
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
S. YORKS.—		
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
MIDLANDS—		
Crown Bars	9 15 0	—
Marked Bars (Staffs.)	12 0 0	—
Nut and Bolt Bars	7 5 0 to 7 15 0	—
SCOTLAND—		
Crown Bars	9 12 6	9 5 0
Best	10 2 6	9 15 0
N.E. COAST—		
Common Bars	9 12 6	8 15 0
Best Bars	10 2 6	9 15 0
Double Best Bars	10 12 6	10 0 0

STEEL.

	Home.	Export.
LONDON AND THE SOUTH—	£ s. d.	£ s. d.
Angles	8 10 0	7 7 6
Tees	9 10 0	8 7 6
Joists	8 17 6	7 7 6
Channels	8 15 0	7 12 6
Rounds, 3in. and up	9 10 0	8 7 6
„ under 3in.	8 14 6	—
Flats, 5in. and under	8 14 6	7 2 6
Plates, ¾in. (basis)	9 0 0	7 15 0
„ ⅞in.	9 5 0	8 0 0
„ 1in.	9 10 0	8 5 0
„ 1⅛in.	9 15 0	8 10 0
„ 1¼in.	9 10 0	8 5 0
NORTH-EAST COAST—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Plates, ¾in.	8 15 0	7 15 0
„ ⅞in.	9 0 0	8 0 0
„ 1in.	9 5 0	8 5 0
„ 1⅛in.	9 10 0	8 10 0
„ 1¼in.	9 5 0	8 5 0
Boiler Plates, ¾in.	9 5 0	8 5 0
MIDLANDS, AND LEEDS AND DISTRICT—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¾in. (basis)	8 17 6	7 15 0
„ ⅞in.	9 2 6	8 0 0
„ 1in.	9 7 6	8 5 0
„ 1⅛in.	9 12 6	8 10 0
„ 1¼in.	9 7 6	8 5 0
Boiler Plates, ¾in.	9 7 6 . 7 15 0	to 8 5 0

STEEL (*continued*).

	Home.	Export.
GLASGOW AND DISTRICT—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¾in. (basis)	8 15 0	7 15 0
„ ⅞in.	9 0 0	8 0 0
„ 1in.	9 5 0	8 5 0
„ 1⅛in.	9 10 0	8 10 0
„ 1¼in.	9 5 0	8 5 0
Boiler Plates	9 5 0	8 5 0
SOUTH WALES AREA—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 0
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¾in. (basis)	8 17 6	7 15 0
„ ⅞in.	9 2 6	8 0 0
„ 1in.	9 7 6	8 5 0
„ 1⅛in.	9 12 6	8 10 0
„ 1¼in.	9 10 0	8 5 0

IRELAND—	BELFAST. £ s. d.	REST OF IRELAND. £ s. d.
Angles	8 12 6	8 15 0
Tees	9 12 6	9 15 0
Joists	9 0 0	9 2 6
Channels	8 17 6	9 0 0
Rounds, 3in. and up	9 12 6	9 15 0
„ under 3in.	9 2 0	9 4 6
Plates, ¾in. (basis)	9 0 0	9 2 6
„ ⅞in.	9 5 0	9 7 6
„ 1in.	9 10 0	9 12 6
„ 1⅛in.	9 15 0	9 17 6
„ 1¼in.	9 12 6	9 15 0

OTHER STEEL MATERIALS.

	Home. £ s. d.	Export. £ s. d.
Sheets.		
10-G. to 13-G., f.o.r.	9 0 0	8 15 0
14-G. to 20-G., d/d	10 5 0	9 0 0
21-G. to 24-G., d/d	10 10 0	9 5 0
25-G. to 27-G., d/d	11 2 6	9 17 6

The above home trade prices are for 4-ton lots and over; 2-ton to 4-ton lots, 10s. per ton extra; and under 2-ton lots, 30s. per ton extra.

Galvanised Corrugated Sheets, Basis 24-G.

Home.	£ s. d.
4-ton lots and up	13 0 0
2-ton to 4-ton lots	13 7 6
Under 2 tons	15 0 0

Export: £16 12s. 6d., c.i.f. duty paid India.
„ £11 5s. 0d., f.o.b. other markets.
„ Scandinavian Markets free.

Tin-plates.
20 by 14 basis, f.o.b. Bristol Channel ports, 18/2.
Tin-plate Bars, d/d South Wales Works, £5 7s. 6d.

Billets.	£ s. d.
Basic (0·33% to 0·41% C.)	6 12 6
„ Medium (0·42% to 0·60% C.)	7 2 6
„ Hard (0·61% to 0·85% C.)	7 12 6
„ „ (0·86% to 0·99% C.)	8 2 6
„ „ (1% C. and up)	8 12 6
Soft (up to 0·25% C.), 500 tons and up	5 10 0
100 tons	5 15 0
Rails, Heavy, 500-ton lots, f.o.t.	8 10 0
„ Light, f.o.t.	7 10 0

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	3/3 per lb.	
Ferro Tungsten	3/– per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£23 0 0	7/–
„ „ 6 p.c. to 8 p.c.	£21 12 6	7/–
„ „ 8 p.c. to 10 p.c.	£21 12 6	7/–
„ „ Specially Refined		
„ „ Max. 2 p.c. carbon	£34 0 0	11/–
„ „ „ 1 p.c. carbon	£38 15 0	12/–
„ „ „ 0·70 p.c. carbon	£42 0 0	12/6
„ „ „ carbon free	10d. per lb.	
Metallic Chromium	2/5 per lb.	
Ferro Manganese (loose)	£10 5 0 home	
„ Silicon, 45 p.c. to 50 p.c.	£13 0 0 scale	5/– p.u.
„ „ 75 p.c.	£18 7 6 scale	6/– p.u.
„ Vanadium	12/8 per lb.	
„ Molybdenum	5/3 per lb.	
„ Titanium (carbon free)	9d. per lb.	
Nickel (per ton)	£200 to £205	
Ferro Cobalt	5/3d. per lb.	

NON-FERROUS METALS.

Official Prices, December 12th.

COPPER—		
Cash	£27 13 9 to £27 15 0	
Three months	£28 1 3 to £28 2 6	
Electrolytic	£31 0 0 to £31 10 0	
Best Selected Ingots, d/d Birmingham	£31 15 0	
Sheets, Hot Rolled	£58 0 0	
	Home.	Export.
Tubes, Solid Drawn (basis)	9½d.	9½d.
„ Brazed (basis)	9½d.	9½d.
BRASS—		
Ingots, 70/30, d/d Birmingham	£27 0 0 to £29 0 0	
	Home.	Export.
Tubes, Solid Drawn, 2/1 Alloy	8¾d.	8¾d.
„ Brazed	10¾d.	10¾d.
TIN—		
Cash	£228 10 0 to £228 12 6	
Three months	£228 10 0 to £228 12 6	
LEAD	£10 2 6 to £10 8 9	
SPELTER	£11 13 9 to £11 17 6	
Aluminium Ingots (British)	£100	

FUELS.

SCOTLAND.

	Export.
LANARKSHIRE—	
(f.o.b. Grangemouth)—Navigation Unscreened	13/– to 13/6
„ Glasgow—Ell	15/6
„ „ Splint	17/–
AYRSHIRE—	
(f.o.b. Ports)—Steam	14/– to 14/6
FIFESHIRE—	
(f.o.b. Methil or Burntisland)—Prime Steam	14/–
Unscreened Navigation	12/6 to 13/–
LOTHIANS—	
(f.o.b. Leith)—Hartley Prime	13/6
Secondary Steam	13/–

ENGLAND.

YORKSHIRE, MANCHESTER—	
B.S.Y. Hard Steams	18/6 to 21/6
Furnace Coke	13/– to 17/6
NORTHUMBERLAND, NEWCASTLE—	
Blyth Best	14/3 to 14/6
„ Second	13/– to 13/3
„ Best Small	10/6 to 11/–
Unscreened	12/6 to 13/6
DURHAM—	
Best Gas	14/8
Foundry Coke	18/6 to 22/6

SHEFFIELD	Inland.	
Best Hand-picked Branch	24/– to 26/–	—
South Yorkshire Best	21/– to 23/–	—
South Yorkshire Seconds	17/6 to 19/–	—
Rough Slacks	8/– to 9/–	—
Nutty Slacks	7/– to 8/6	—

SOUTH WALES.

CARDIFF—	
Steam Coals:	
Best Admiralty Large	19/6
Seconds	19/– to 19/4½
Best Dry Large	18/9 to 19/3
Ordinaries	18/3 to 18/6
Best Bunker Smalls	13/6 to 14/–
Cargo Smalls	11/6 to 12/6
Dry Nuts	22/– to 26/–
Foundry Coke	24/– to 37/6
Furnace Coke	19/– to 21/6
Patent Fuel	21/–
SWANSEA—	
Anthracite Coals:	
Best Large	37/6 to 40/–
Machine-made Cobbles	41/– to 51/–
Nuts	40/– to 50/–
Beans	25/– to 30/–
Peas	19/– to 22/6
Rubbly Culm	11/6 to 12/–
Steam Coals:	
Large	17/– to 20/6

FUEL OIL.

Inland consumption; contracts in bulk.
Exclusive of Government tax of 1d. per gallon.

Ex Ocean Installation.	Per Gallon.
Furnace Oil (0·950 gravity)	3½d.
Diesel Oil	4d.

Manchester prices ½d. per gallon extra.

French Engineering Notes.

(From our own Correspondent in Paris.)

Trade Tendencies.

THE present industrial stalemate leaves little matter for discussion except the ways and means of bringing about a trade recovery on lines that will ensure the prosperity of home industries and an active development of foreign trade. There are to be further conferences on the adjustment of production to demand and the lowering of charges on industry. The Imperial Conference aims at uniting France and her Colonies into an economic whole, with a view to the home market absorbing more Colonial products and thereby increasing Colonial purchases of manufactured goods. Plans are being discussed for a new policy of foreign trade expansion that will facilitate exchanges without entailing too great a sacrifice on home industries. The success of these plans is dependent on the sacrifices that home producers may be disposed to make. Most industrialists are aware that their interests lie in an organised control of production and the suppression of artificial aids to industries that cannot exist in the face of competition. The issue of the Imperial Conference depends on sacrifices being made by producers outside the engineering, metallurgical, and allied industries, and even within them foreign trade cannot be expanded without concessions on the part of certain manufacturing industries that were created solely to supply the home market to the exclusion of foreign products.

Quality and Prompt Delivery.

One of the contributory causes of the industrial collapse is admittedly the late vogue for quantity production with less regard to quality, and the importance now attached to individual skill for the manufacture of high-quality goods is intended to divert effort from mass production to products that can be sold on their merits, irrespective of price competition. Industrial prosperity in the past depended on goods that commanded markets all over the world because similar products of the same quality could not be procured elsewhere. Those markets are now closed, and some essentially French industries are on the verge of ruin. Quality is therefore again insisted upon as offering a means of retrieving trade by permitting the removal of obstacles to foreign exchanges. In the same way, consistent quality and economy in the engineering industries are stressed in the propaganda work of the Union des Industries Métallurgiques et Minières, de la Construction Mécanique, Electrique et Métallique, which, as the name implies, covers the whole of the engineering, metallurgical, electrical, and allied trades throughout the country. It has a department for the scientific organisation of work, and holds periodical exhibitions, each devoted to a special phase of the problem. An exhibition now being held at the headquarters of the Union in Paris deals with the commercial and economical value of adhering strictly to dates of delivery. Consequences arising from failure to observe punctual delivery are shown by diagrams and illustrations, and the conclusion impressed upon visitors is that price is not the only factor that counts in the distribution of orders. Preference, it is urged, should be given to makers who keep their promises. Customers are often responsible for delays in delivery, and salesmen should therefore be adequately trained in the methods of manufacturing the goods they handle. This strict observance of promises given to customers implies a scientific tabulation of work going through shops, and various systems employed by leading firms are shown, demonstrating that it is by no means an easy matter to indicate at a glance the progress of any particular order in a works turning out a large variety of products.

Scrapping Textile Machinery.

In view of the loss of foreign markets, particularly the British, textile manufacturers in the Nord have so far abandoned hope of ever getting back all their former connections that they have endeavoured to rationalise the industry by scrapping redundant plant and organising production in a manner that will enable the industry to be carried on under more normal conditions. All these attempts have met with opposition from a minority of small firms, and the textile industry has been going from bad to worse, with the closing down of factories and the throwing of thousands of hands out of work. Amongst them was the Bouteny factory at Willems, near Lille. An announcement some months ago that the firm intended to destroy superfluous looms aroused opposition from the discharged men, who declared that they would prevent such destruction. Consequently, when it was rumoured last week that looms were being scrapped, the men invaded the factory and had to be expelled by force. They appointed a committee to watch over the factory and threatened that any attempt to destroy the looms would be the signal for the mobilisation of all the weavers in the district.

Rolling Stock.

The Conseil Supérieur des Chemins de Fer has sanctioned the expenditure of more than 500 million francs on rolling stock during 1935, and though locomotive and wagon builders regard this expenditure as inadequate, in view of the small amount of work that was distributed during the past two years, the orders will at least avoid the necessity of closing down additional shops and further depleting the ranks of skilled hands who have had to seek other occupations. The railway companies continue to experiment with different types of rail cars. A "Sentinel" steam rail car has been built in France for the Compagnie du Nord, and will undergo its official tests shortly. This is the only steam vehicle yet tried on French lines. The arrival of the "Cock o' the North" locomotive at the Vitry-sur-Seine testing bench last week-end aroused considerable interest in view of its being the first British locomotive to run on French lines since the war and of its demonstrating the international utility of the Vitry locomotive testing station.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

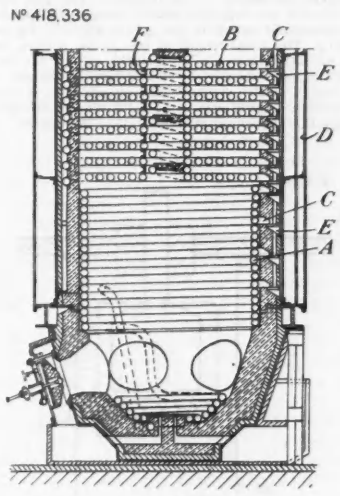
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

STEAM GENERATORS.

418,336. February 3rd, 1934.—COILED WATER-TUBE STEAM GENERATORS, *The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C.2.*

In steam generators having tubes in spirally or helically arranged coils, it is not possible to remove single coils alone. According to the invention, this disadvantage is avoided. The steam generator consists in part of tube coils A wound in the form of a close helix, and in part of spirally wound stacks of tube coils B. The coils are supported by the boiler casing D by means of lugs C welded on the pipes, the lugs C resting on small brackets E secured to the boiler casing. With the spirally

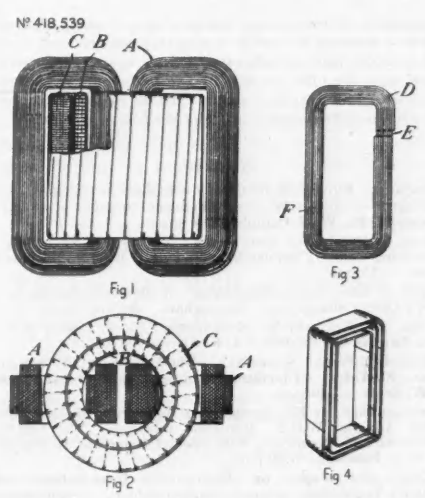


wound coils, it will be sufficient if the turns lying at the outside are provided with the welded-on lugs C and the inner turns can be supported upon supporting irons F, which can rest on the outer turns of the layer of pipes lying beneath them. For the support of the helical coils, it is not necessary to provide each turn with the welded-on supporting lugs, but it will be sufficient if, as illustrated, each fourth turn is provided with a supporting lug. Owing to the fact that each of the spirally wound layers is independently supported, the possibility is provided of withdrawing single layers of tube coils without the necessity of removing the whole of the coils above them.—*October 23rd*, 1934.

TRANSFORMERS AND CONVERTERS.

418,539. November 22nd, 1933.—MAGNETIC CORES, *The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C.2.*

The transformer shown includes a two-part magnetic core A, with windings B and C surrounding the adjacent sides of the two parts. Each of the two parts of the core A includes a large centre section with a smaller section at each side to fill in more completely the cylindrical space surrounded by the windings. The sections of the core may be alike, except as regards size. Each section of the core is formed from flat strip D of magnetic sheet material of suitable width, wound flatwise into a hollow coil, with enough turns to give the coil the required thickness and cross section. In forming the core the wound magnetic coil is

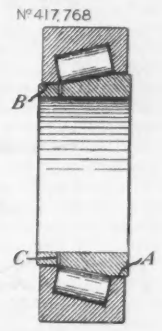


separated into two parts by two cuts E and F, the coil being annealed after the cuts are made. The turns are reassembled around the windings B and C, as indicated in Figs. 1 and 2, with part of the turns reversed in position so that the joints between their sections are displaced, alternate turns being reversed. Fig 4 is a perspective diagrammatic view of three successive turns showing how the joints between the sections of these turns are offset after alternate turns are reversed. After the coil has been wound, as in Fig. 3, but before the cuts E and F have been made, the turns are arranged end to end in the coil with adjacent ends of the turns offset, as indicated at the cut E in Fig. 3. The turns are reassembled, as indicated in Figs. 1 and 4, with the ends of each turn meeting each other and close together. Thus, the two parts of the coil are reassembled to form a magnetic core which includes two parts connected by interleaved joints and with each turn closed. When reassembled, as indicated in Figs. 1 and 4, each turn and therefore the completed core is shorter than the wound coil by an amount equal to the length of each gap formed by the cuts E and F. The strip D is therefore wound to form a coil longer than the desired length of the completed core by an amount equal to the length of the gaps formed by the cuts.—*October 26th*, 1934.

TRANSMISSION OF POWER.

417,768. April 7th, 1934.—TAPER ROLLER BEARINGS, *H. N. Skerrett, 24, Temple-row, Birmingham.*

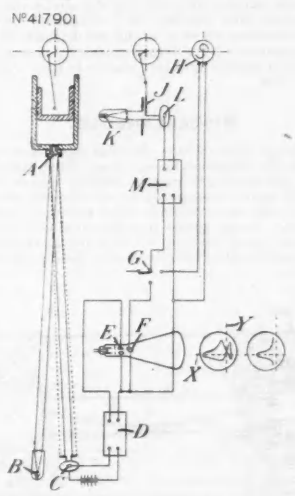
It is suggested that under excessive conditions of loading, the rollers of taper roller bearings may be deformed to such an extent that they cease to perform their normal functions, and the bearing is destroyed. In such circumstances the inventors propose that the roller races should take up the load as in a plain journal bearing. The bearing surfaces are then provided by the parallel portions A B, which are said to be lubricated through the passages C by the pumping action of the rollers.—*October 11th*, 1934.



MEASURING AND TESTING INSTRUMENTS.

417,901. November 9th, 1933.—HIGH-SPEED INDICATORS, Société Anonyme Hewittic, 11, Rue du Pont, Suresnes, France, M. Demontvignier, 11, Rue du Pont, and A. Labarthe, 16, Rue Saint Simon, Paris, France.

This indicator is intended for making graphs showing the pressure variations during each cycle of very high-speed internal combustion engines. A diaphragm A is inserted in the cylinder head and is illuminated by a lamp B. Light reflected from the diaphragm is picked up by the photo-electric cell C, the consequent electric current is amplified at D, and is taken to the

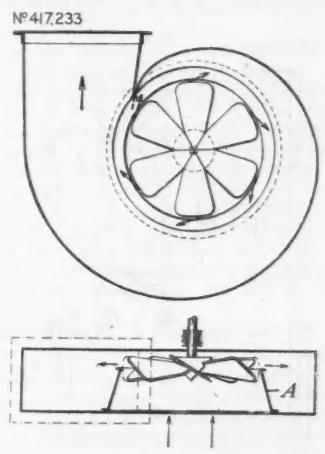


deflecting plates E of a cathodic oscillograph, which causes deflections of the cathodic beam in the direction X of the screen. The other pair of deflecting plates F of the oscillograph is subjected to a varying voltage which causes a deflection of the beam in the direction Y. This voltage can be changed at will by the switch G, and may be obtained in several ways. One is shown in the alternator H, keyed on the shaft of the engine and another in the shutter J, also driven by the engine, that controls light from the source K falling on the photo-electric cell L and amplified at M.—*October 15th*, 1934.

PUMPING AND BLOWING MACHINERY.

417,233. April 4th, 1934.—FANS OR BLOWERS, Sulzer Frères Société Anonyme, Winterthur, Switzerland.

This fan is of the propeller type, but it is housed in a volute casing. The inlet duct A is extended to half the width of the



propeller, from which the discharge is tangential. The outer ends of the blades are rounded off so that the air drawn in close to the inlet casing does not suddenly impinge on the blades and cause noise.—*October 1st*, 1934.

418,420. April 27th, 1934.—DEVICE FOR PRODUCING A UNIFORM DRAUGHT IN FUNNELS, Richard Göllner, of 46, Adolf Hitlerstrasse, Burg. b./Magdeburg, Germany.

In accordance with this invention two superposed rotating fans, each having three blades, are caused to rotate in opposite

directions by the exhaust in smoke funnels with the object of obtaining a uniform draught. The lower fan or rotor A is mounted on the shaft B, and the upper fan or rotor C on the hollow shaft D, which rests in the ball bearings E and F housed in a casing G. The inner shaft B rests in the upper bearing H, and in the lower bearing J, the housing K of which is supported by the rods L resting against the wall of the funnel. A protective tube M is connected to the housing K in order to prevent spreading of oil. The lubricant enters at N at the upper cover, goes partially through the bearing H into the hollow of the case

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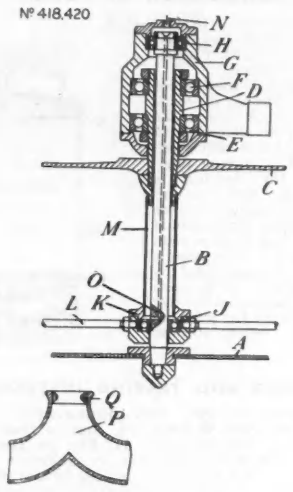

G, and from there through the bearings F and E. The oil, which must be capable of withstanding very high temperatures, also flows through the boring O in the shaft downwards to the bearing J. In the orifice of the exhaust pipe P a ring Q is inserted for the purpose of increasing the outlet velocity of the exhaust steam, so that between the two fans or rotors running in opposite directions there is a uniform cushion of the gases, which prevents sparks from flying out and by means of which it is also possible to keep a uniform pressure in the exhaust pipe.—*October 24th*, 1934.

MISCELLANEOUS.

417,512. March 29th, 1933.—VALVES FOR HOT GASES, H. Rappold, 22, Viktoriastrasse, Düren, Rhineland, Germany.

Instead of attempting to cool by exterior means the working parts of valves used to control highly heated gases under medium temperatures, the inventor makes the essential parts of heat-resistant metal. In the casing A is movably mounted the valve B, which in its closed position abuts either against the seating ring C or D, according to the direction of flow of the gases. The

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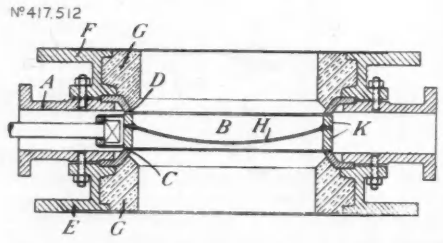

valve consists of a thin arched plate H of a steel capable of withstanding a high temperature which is welded to the ring K. The ring is attached to a rod for actuating the valve. The arched shape of the plate H has the advantage that it offers great resistance to the hot gas to be regulated, and, consequently, can be made of relatively thin material. The seatings C and D are made of bent or dished rings of heat-resistant steel, having seating surfaces the planes of which are obliquely disposed to the annular walls of the rings.—*October 1st*, 1934.

417,663. April 7th, 1933.—ELECTRIC SYNCHRONISED MOTION TRANSMISSION SYSTEMS, The English Electric Company, Ltd., of Queen's House, 28, Kingsway, London, W.C.2, and Reginald Donahoe Ball, of Phœnix Works, Bradford, Yorkshire.

The drawing shows the invention as arranged for enabling motion in three-dimensional space to be reproduced. A group of three induction motors A, B, and C, with wound rotors and

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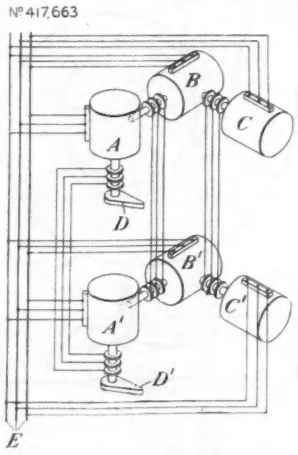

slip rings, has the stator of the second motor B mounted on the shaft of C, and the stator of A on the shaft of the second motor, all three shafts being substantially at right angles. With a unit of this kind it is possible to move a point on the lever arm D mounted on the shaft of the motor A in any direction in space within the limits of movement of the apparatus. One or more further units, each comprising motors A′, B′, and C′ and a lever arm D′, are similarly arranged. The stators of all the motors are fed from common three-phase A.C. supply mains E, while the rotors of corresponding motors in each group are connected in parallel. Thus the angular movement of each shaft in one unit will be precisely transmitted to the shafts of the other units and the three-dimensional motion given, for example, to the point on the lever arm D will be precisely reproduced by a similar point on each of the arms D′ of the other units. The operation is based on the fact that when two or more induction motors have their secondaries connected in parallel the voltage induced in the secondary windings will cancel one another in a certain relative position of the rotors, with the result that in this position no torque is produced and the rotors remain stationary. But if one rotor be moved to another position torque will be produced and the other rotors will tend to take up a corresponding position. Numerous application of this invention are possible. For example, tools mounted on members D′ may be cutting tools for forming simultaneously several three-dimensional objects, such as sculptured objects.—*October 8th*, 1934.

417,853. March 13th, 1933.—MERCURY VAPOUR RECTIFIERS, The General Electric Company, Ltd., of Magnet House, Kingsway, London, W.C.2, and Enrico Gallizia, of the General Electric Company, Ltd., Engineering Works, Witton, Birmingham.

This invention relates to vapour arc converters controlled in such a way that under normal operating conditions striking of the arc occurs only if suitable control potentials are applied to control grids associated with the anodes, an object being the provision of improved grid arrangements for use with vapour arc converters controlled in this manner. The grid comprises a ring or sleeve A of somewhat smaller diameter than the anode sleeve H within and on which the grid is mounted by means of insulators C. The axial length of the sleeve A may be about one-third of its diameter. Within the sleeve are strips D, secured at their ends to the sleeve and having a width equal to the axial length of the sleeve A and, in addition, a number of strips or wires E located in a plane substantially at right angles to the strips D, and secured at their ends to the sleeve. In cross

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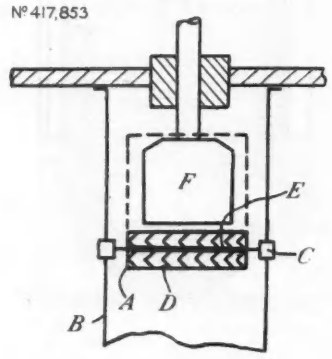

section the strips D are of W shape, so that between adjacent strips there is a zigzag channel. Preferably the strips E are inclined to the axis of the anode sleeve B. The grid constituted by the sleeve A and the strips D and E is disposed adjacent to the working surface of the anode F and it will be seen that the upper edges of the strips D are inclined relatively to the working surface. The strips D therefore exert a directive effect on the arc. Preferably the grids, for example, of a rectifier, are arranged so that the upper edges of the strips D are inclined outwardly from the centre of the rectifier. In the arrangement described, large de-ionising surfaces are accommodated in grids of relatively short length and the grids force the arc stream to follow indirect paths, with the result that an effective blocking effect is obtained by grids of compact construction. Moreover, since it is possible for one and the same grid to serve as the blocking grid and the grid to which the control potential is applied, the arrangement is particularly simple.—*October 15th*, 1934.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

CHEMICAL ENGINEERING GROUP.—Rooms of Chemical Soc., Burlington House, W.1. "Chemical Aspect of Timber Research," Mr. W. G. Campbell. 8 p.m.

INST. OF ELECTRICAL ENGINEERS: N. EASTERN STUDENTS.—Armstrong College, Newcastle-upon-Tyne. Impromptu Speech Night. 7.15 p.m.

INST. OF ELECTRICAL ENGINEERS: S. MIDLAND STUDENTS.—Boot's Café, Colmore-row, Birmingham. Annual dance.

INST. OF MECHANICAL ENGINEERS.—Storey's-gate, S.W.1. "Air Swirl in Oil Engines," J. F. Alcock. 6 p.m.

INST. OF METALS: SHEFFIELD.—The University, St. George's-square, Sheffield. "Rhodium Plating and its Application," Mr. A. W. Scott. 7.30 p.m.

JUNIOR INST. OF ENGINEERS.—At Royal Soc. of Arts, John-street, Adelphi, W.C.2. Inaugural meeting, "The Lighting of Streets and Roadways, with special Reference to Safety," Mr. C. C. Paterson. 7.30 p.m.

KEIGHLEY ASSOC. OF ENGINEERS.—Inter-lecture with Keighley Textile Soc. Queen's Hotel, Keighley. "Lubricants—The Relation between Laboratory and Engine Tests," Mr. F. L. Slee. 7.30 p.m.

N. EAST COAST INST. OF ENGINEERS AND SHIPBUILDERS.—Mining Inst., Newcastle-upon-Tyne. "Production in Engineering Works," Mr. J. C. Green. 6 p.m.

RAILWAY CLUB.—At Broad-street Station Restaurant, E.C. Annual dinner. 7 for 7.30 p.m.

ROYAL SOC. OF ARTS.—John-street, Adelphi, W.C.2.—"Indian Forestry: Economic and Commercial Aspects," Mr. A. D. Blaschеck. 4.30 p.m.

WEST OF SCOTLAND IRON AND STEEL INST.—Royal Technical College, Glasgow. "The Influence of Design on Effective and Economical Operation of Rolling Mills," Mr. T. W. Hand. 7.15 p.m.

FRIDAY AND SATURDAY, DEC. 14TH AND 15TH.

BOROUGH POLYTECHNIC.—Borough-road, S.E.1. Exhibition of Students' Works. Friday, 6–9 p.m.; Saturday, 2.30 to 9.30 p.m.

SATURDAY, DEC. 15TH.

INST. OF CIVIL ENGINEERS: STUDENTS.—Visit to Building Research Station, near Watford.

INST. OF ELECTRICAL ENGINEERS: N. EASTERN STUDENTS.—Visit to works of Messrs. Clark, Chapman and Co., St. James'-road, Gateshead-on-Tyne. 2.30 p.m.

INST. OF METALS: N. EAST COAST LOCAL SECTION.—Joint meeting with Inst. of British Foundrymen. Armstrong College, Newcastle-upon-Tyne. "Problems in Non-ferrous Foundry Practice," Mr. F. W. Howe. 7.30 p.m.

MANCHESTER ASSOC. OF ENGINEERS.—At College of Technology, Manchester. Conversazione and dance. 6.45 to 11.30 p.m.

NORTH OF ENGLAND INST. OF MINING AND MECHANICAL ENGINEERS.—In the Lecture Theatre of the Institute, Newcastle-upon-Tyne. Discussion, "Winding Accidents: Their Cause and Prevention," Mr. E. H. Oliver; "The Correlation of Coal Seams by Microspore-Content; Part I, The Seams of Northumberland," Dr. Arthur Raistrick; paper, "Suggested Applications of Photo-electric Cells to Mining," Dr. E. G. Richardson. 2.30 p.m.

MONDAY, DEC. 17TH.

INST. OF MECHANICAL ENGINEERS: GRADUATES.—Joint meeting with Inst. of Electrical Engineers, London Students. Storey's-gate, S.W.1. "Overhaul of Electric Railway Stock," Mr. E. McEwen. 6.15 for 6.45 p.m.

INST. OF STRUCTURAL ENGINEERS: MIDLAND COUNTIES BRANCH.—James Watt Memorial Inst., Birmingham. "The Maintenance and Repair of Small Highway Bridges," Mr. J. H. N. Wilkes. 6.30 p.m.

WOLVERHAMPTON AND DISTRICT ENGINEERING SOC.—Victoria Hotel, Wolverhampton. "The Commercial Production of Oxygen and Hydrogen by Electrolysis of Water," Mr. A. E. Knowles. 7.30 p.m.

TUESDAY, DEC. 18TH.

BRITISH ASSOC. OF REFRIGERATION.—At Inst. of Marine Engineers, 85/88, The Minories, E.C.3. Symposium of Short Papers on Air Conditioning: "The Importance of Air Distribution in Air Conditioning," Mr. L. J. Fowler; "Air Conditioning with Refrigeration in Breweries," Mr. H. S. Harker; "Air Conditioning, including some Notes on the British Museum Installation," Mr. J. Macintyre; "Refrigeration as Applied to Air Conditioning and Cooling by Direct Radiation in Rooms," Mr. J. L. Musgrave. 6.30 p.m.

CHEMICAL ENGINEERING GROUP.—Hotel Great Central, Marylebone, W. Annual Chemical Dinner.

CRYSTAL PALACE SCHOOL OF PRACTICAL ENGINEERING.—186th award of certificates. Chairman, Mr. H. C. Adams. 3 p.m.

INST. OF CIVIL ENGINEERS.—Great George-street, S.W.1. Discussion, "The Perak River Hydro-electric Power Scheme," Mr. B. M. Hellstrom; "The Construction of the Chenderoh Water Power Plant of the Perak River Hydro-electric Power Scheme," Mr. W. J. H. Rennie. 6 p.m.

INST. OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—39, Elmbank-crescent, Glasgow, C.2. "A New Type of Marine Steam Engine," Mr. G. R. Grange. 7.30 p.m.

INST. OF METALS: BIRMINGHAM LOCAL SECTION.—James Watt Memorial Inst., Birmingham. "Interpretation of the Equilibrium Diagram," Dr. N. P. Allen. 7 p.m.

INST. OF STRUCTURAL ENGINEERS: SCOTTISH BRANCH.—At 15, Rutland-square, Edinburgh. "Examination of Welded Joint," Mr. T. S. Glover. 7.15 p.m.

SHEFFIELD METALLURGICAL ASSOC.—198, West-street, Sheffield, 1. "X-ray Examination of Metals, with some Results," Dr. P. Jay. 7.30 p.m.

WEDNESDAY, DEC. 19TH.

BRITISH SCIENCE GUILD.—Royal Soc. of Arts, John-street, Adelphi, W.C.2. "Bringing Science into the Road Traffic Problem," Colonel Mervyn O'Gorman. Discussion. 5 p.m.

INST. OF AUTOMOBILE ENGINEERS.—Hotel Metropole, Leeds. "Functions of Mechanical Power in Soil Cultivation," Dr. B. A. Keen; "Some Features of Modern Tractor Design," Mr. S. J. Wright. 7.15 p.m.

INST. OF AUTOMOBILE ENGINEERS.—Engineers' Club, Manchester. "Electric Discharge Lamps and their Application to Road Lighting," Messrs. H. Warren and L. J. Davies. 7 p.m.

INST. OF CHEMICAL ENGINEERS.—In Rooms of Chemical Soc., Burlington House, W.1. "Separation of Solids from Liquids (Thickening)," Dr. Wm. Cullen and Mr. H. T. Durant. 6 p.m.

INST. OF CIVIL ENGINEERS.—Students' meeting. Great George-street, S.W.1. Institution lecture, "Modern Methods and Plant for Excavations," Sir Henry Japp. 6.30 p.m.

N. EAST COAST INST. OF ENGINEERS AND SHIPBUILDERS: GRADUATE SECTION.—Bolbec Hall, Newcastle-upon-Tyne. "Cooling of Electrical Machinery," Mr. R. A. Morris. 7.15 p.m.

ROYAL MICROSCOPICAL SOC.—B.M.A. House, Tavistock-square, W.C.1. Meeting at 5 for 5.30 p.m.

THURSDAY, DEC. 20TH.

INST. OF CIVIL ENGINEERS: BIRMINGHAM AND DISTRICT ASSOC.—Visit to City of Birmingham Windsor-street gasworks to inspect repairs to reinforced concrete by cement gun method. 2.15 p.m.

INST. OF ELECTRICAL ENGINEERS.—Savoy-place, W.C.2. "Organisation of Ejectricity Supply in New Zealand," Mr. F. T. M. Kissel. 5.30 for 6 p.m.

INST. OF MARINE ENGINEERS: JUNIOR SECTION.—The Minories, E.C. "The Production of Aluminium and some of its Applications to Marine Engineering," Mr. G. A. Anderson. 7 p.m.

INST. OF STRUCTURAL ENGINEERS.—10, Upper Belgrave-street, S.W.1. Ordinary general meeting for election of members. 6.30 p.m.

N. EAST COAST INST. OF ENGINEERS AND SHIPBUILDERS: TEES-SIDE BRANCH.—At Cleveland Scientific and Technical Inst., Corporation-road, Middlesbrough. "Metallurgical Aspects of Certain Recent Industrial Developments," Dr. W. P. Inglis. 7.30 p.m.

FRIDAY, DEC. 21ST.

ELECTRO-DEPOSITORS' TECHNICAL SOC.—James Watt Memorial Inst., Birmingham. "Barrel Plating Technique," Mr. E. J. Dobbs. 7.30 p.m.

INST. OF BRITISH FOUNDRYMEN: JUNIOR SECTION.—College of Technology, Sackville-street, Manchester. "Cupola Practice," Mr. J. Jackson. 7.30 p.m.

JUNIOR INST. OF ENGINEERS.—39, Victoria-street, S.W.1. Lecture, "Regulations and Rules Affecting Luminous Discharge Tube Installations." 7.30 p.m.

SATURDAY, DEC. 22ND.

SHEFFIELD METALLURGICAL ASSOC.—198, West-street, Sheffield, 1. Young people's Christmas party. 3.30 p.m.

A Seven-Day Journal

The Internal Combustion Engine Group.

A WELL-ATTENDED meeting of members of the Institution of Mechanical Engineers and kindred institutions took place on Friday evening last, December 14th, when the first sectional group within the Institution was officially inaugurated by the President, Mr. Charles Day. Mr. Day announced that an *ad hoc* committee had been appointed to look after the affairs of the group until next March. It consists of the President, Colonel A. E. Davidson, Wing-Commander Cave-Brown-Cave, Dr. S. J. Davies, Mr. C. S. Dicksee, Mr. D. R. Pye, and Mr. W. A. Tookey. Mr. Day asked those present for suggestions as to the working of the group. There was a good response to his request, and the opinion of the committee was generally affirmed, that the meetings should be informal in character and that invitations to attend them might be issued to all workers in the field of internal combustion engineering, whether land, marine, road transport, or aircraft engines. It was recommended that a spring meeting should be held in three sessions on Monday and Tuesday, March 25th and 26th, when short papers would be presented to serve as a basis for discussion. Such subjects as scavenging and supercharging, gas engine design, and methods of engine testing, including the testing of very high-speed engines, are among those which were put forward. The proposal was also made that a general account of the discussions, together with a brief abstract of the papers, might be printed in the "Transactions." Up to the present over eighty-four members have joined the new group.

New Trinidad Harbour Works.

THE announcement is made that the Crown Agents for the Colonies have awarded to Edmund Nuttall, Sons and Co. and John Mowlem and Co., Joint, Ltd., of 91, Ebury Bridge-road, London, S.W.1, a contract for new harbour works at the Port of Spain, Trinidad. These works will include the construction of a deep-water wharf, together with the dredging of a suitable approach channel and basin and other contingent works. The total expenditure on the new harbour and its equipment will, it is expected, involve a total expenditure of close upon £950,000. This amount, we are informed, will include the first cost of a dredger and tugs, which will be required for maintenance work. The carrying out of the complete scheme will occupy about four years. It will be assisted by a free grant from the Colonial Development Fund of the net interest on the constructional costs, both during the period of construction and for one year thereafter. The scheme has been prepared by Messrs. Coode, Wilson, Mitchell and Vaughan Lee, consulting engineers, of Westminster, to whose specifications and requirements the work will be carried out.

Oil from Empire Minerals.

FOLLOWING a long series of tests, an order has been placed with Salermo, Ltd., of London, for two complete units for the manufacture of low-temperature liquid fuel in South Africa. They are to be installed in the torbanite deposit district of Ermelo in the Transvaal, where, under the encouragement of the South African Government, mining and refining operations are being carried out on an extensive scale by the South African Torbanite Mining and Refining Company, Ltd., as reported by our South African correspondent in our last issue. Each of the two plants is to be capable of treating 150 tons per day, and tests have indicated, we are informed, that yields as high as 100 gallons of crude oil per ton can be obtained from the richer deposits. The complete equipment, which will cost about £50,000, will be manufactured in this country by Robert Dempster and Sons, Ltd., of Elland, Yorkshire. The working of the new plants will be watched with considerable interest in South Africa, and it is hoped that a large output of petrol, lubricating, and fuel oils will be made available. Other development work of similar character is, we understand, being undertaken in connection with the working of Alberta tar sands in Canada, and the possible supply of home-produced fuels in Australia. With these schemes in hand, a further development of oil produced from Empire minerals may be awaited.

The Retirement of Mr. J. C. Mitchell.

ON Monday, December 31st, Mr. John Christopher Mitchell will sever his connection with the "Underground" companies, with which he has so long been identified, and on Friday, December 14th, Lord Ashfield presided at a meeting held at 55, Broadway, Westminster, when a presentation was made to Mr. Mitchell. He was born at Birmingham in 1867, and was the son of Christopher Mitchell, whose father, John Mitchell, was the inventor of the steel pen. He received his education at St. Albans School, and in August, 1881, was appointed to the staff of the chief cashier of the Civil Service Supply Association, Ltd. On September 1st, 1886, he became a member of the staff of the secretary of the London Road Car Company, Ltd. Promotion came early, for on April 1st, 1889, he was made the accountant and cashier of the company, and he ultimately succeeded to the secretaryship in 1905. Upon the amalgamation of the omnibus companies in 1908, under the stress of motor omnibus competition, he was appointed secretary to the London General Omnibus Company, Ltd., which had absorbed the Road Car Company and the Vanguard Motorbus Company, Ltd. Later, upon the fusion of interests of the Underground Electric Railway Company of London and the London General Omnibus Company, he was appointed treasurer of the former company, and of the Metropolitan District Railway Company, London Electric Railway Company, City and South London Railway Company, Central London Railway Company, and the London General Omnibus Company, Ltd. In February, 1921, he succeeded to the position of secretary and treasurer of all the companies in the Underground group. On June 30th, 1933, he was secretary of twelve companies and director of three of them. Mr. Mitchell is a member of the Institute of Transport, and a Past-President of the Chartered Institute of Secretaries, in addition to which he finds time for many social and civic activities. His many colleagues and friends will wish him a long and happy period of retirement.

Oil-Engined Omnibuses.

ON Thursday, December 13th, the Corporation of Glasgow revised the allocation of contracts for 110 oil-engined omnibuses and decided that all the bodies for the vehicles shall be built in Glasgow by F. D. Cowieson and Co. Sixty chassis and engines are to be supplied by Leyland Motors, Ltd., of Leyland, Lancashire, and fifty chassis by the Albion Motor Company, Ltd., of Scotstoun. Thirty of these Albion chassis will be equipped with Beardmore engines, constructed by William Beardmore and Co., Ltd., at Dalmuir, and twenty will be fitted with Gardner engines by Norris Henty and Gardners, Ltd., of Patricroft. Gardner engines are also to be fitted in 135 oil-engined omnibuses which have been ordered by the Birmingham Corporation from the Daimler Company, Ltd. Of the 135 omnibuses, 110 are for use with double-deck bodies. The engines will be equipped with the Daimler fluid fly-wheel and a four-speed pre-selector gear-box. When this order has been completed more than half the omnibuses in the fleet of the Birmingham Corporation Transport Department will have fluid fly-wheels.

The Thames Passenger Service Inquiry.

THE London and Home Counties Traffic Advisory Committee has reported to the Minister of Transport upon the public inquiry recently held by the Committee into the question of the desirability and practicability of the provision of a regular service of passenger-carrying boats on the river Thames. The Committee says that there can be no doubt that the provision of such a service is desirable, provided that it is regular, reliable, and comfortable; that the cost to the passenger is not more than by existing travel facilities, and that the water service is so linked up as to form a part of the existing co-ordinated transport services. It adds, however, that the failure of a passenger service on the Thames would prejudice the position for many years to come and therefore no undertaking should be commenced unless the promoters have sufficient financial support to ensure the continuance of the service as a permanent transport facility. As to the practicability of a regular river service, it is stated that the service must fufil a number of conditions, one of which is that the undertaking must be capable of being run so as to be self-supporting. The Committee is not convinced that any such regular service would attract sufficient traffic to be self-supporting, and sees no reason for any Government support at this stage. The Committee is impressed with the fact that no evidence was tendered to show that there was a strong public demand for a river passenger service, and it is not satisfied that there is an essential need for a regular passenger service on the Thames, nor does it appear that such a service would tend to relieve existing land transport facilities.

The Late Col. William McLellan.

IT is with deep regret that we have to record the death at his home in Dalbeattie on Tuesday, December 11th, of Colonel William McLellan, one of the partners in the firm of Merz and McLellan, and until quite recently one of its directors. He was born in Kirkcudbrightshire in 1874, and received his education at Birkenhead and the University of Liverpool. He served his apprenticeship with Cochran and Co., of Birkenhead, and after gaining experience with Siemens Brothers at Woolwich, joined the Cork Tramways Company, and as one of its resident engineers was responsible for the original traction, power, and lighting installations in that city. In 1899 he left Cork to join Mr. Charles H. Merz as a consulting engineer at Newcastle-upon-Tyne, and in 1901 the firm of Merz and McLellan was formed. In his thirty-five years of work in the electric supply industry, Colonel McLellan took a leading part in the development of large electric power undertakings. On the outbreak of war he obtained a commission in the Northumberland Fusiliers, and was proceeding to France when he was appointed by the Government to be Controller of Electric Power Supply. In 1917 he joined the Admiralty and assisted the First Sea Lord as Deputy Director of Experiments and Research. He also visited Italy and America as a member of special Naval Missions. He was made a C.B.E. for his national work and the Italian order of SS. Maurice and Lazarus of Italy was conferred upon him.

A Large Suspension Bridge.

ON Sunday, December 16th, Prince Paul officially opened the new 804ft. span King Alexander I suspension bridge, which has been built across the river Save to connect Belgrade and Zemun. The structure is generally similar in design to the suspension bridge over the Rhine at Cologne, and was jointly constructed by a French and a German firm with materials partly supplied as reparations in kind by Germany. It has taken 4½ years to complete, having been delayed by late deliveries of materials. The total length of the bridge and its approach viaducts is 1967ft., with a clear span of 804ft. The cost is estimated at about £850,000. In addition the State and Municipality of Belgrade, have spent a considerable sum on street clearance and reconstruction schemes, while on the opposite bank an elevated highway of reinforced concrete has been built over 2 miles of marshy flats. The new bridge makes it possible to motor direct from Calais to Constantinople or Athens without ferrying across the Save.

New Shipbuilding Orders.

AN order has been placed by Clan Line Steamers, Ltd., with the Greenock Dockyard Company, Ltd., for the construction of a twin-screw steamer of 10,000 tons deadweight carrying capacity and 16 knots speed to operate on the owner's South African and Australian routes. The machinery will be supplied by the North-Eastern Marine Engineering Company, Ltd., of Wallsend-on-Tyne, and will comprise a combination of triple-expansion steam engines with low-pressure geared turbines. The engines will be equipped with poppet valves designed for superheated steam, and coal-burning boilers, fitted with provision for oil burning, if needed, will be used. It is officially announced that John Brown and Co., Ltd., have been chosen by the Admiralty to build the geared turbine propelling machinery and water-tube boilers, aggregating about 72,000 s.h.p., for the cruiser "Birmingham," which is to be built at Devonport. Other new orders placed on the Clyde include a 5000 gross ton steamer for the Booth Steamship Company, Ltd., to be built at Dumbarton by William Denny and Brothers, Ltd., and an ore-carrying ship of 8000 tons deadweight carrying capacity, which has been ordered from Lithgows, Ltd., of Port Glasgow, by the United Steam Navigation Company, Ltd. (Campbell Brothers and Co.), of Newcastle-upon-Tyne.

Ships' Boilers on the Main Deck.

IN a Journal note of June 29th we made reference to the patented system of elevated boilers developed by Mr. K. G. Meldahl, the managing director of the Fredricksstad and Mek. Verksted A/S, Fredricksstad, Norway. Interest in this departure from hitherto standard marine practice was aroused on Tuesday, December 18th, when Mr. Meldahl invited British shipowners, shipbuilders, and marine engineers to inspect the ss. "Bencas," the second ship to be equipped with deck boilers. The "Bencas" was discharging fruit at the Morocco Wharf, Wapping, and a large company of engineers visited her. She is a cargo ship of 2400 tons deadweight, equipped with semi-uniflow engines and two Scotch coal-fired boilers, giving a designed trial speed of 12½ knots. The boilers are placed on the main deck just abaft the engine-room casing over the fore end of the engine-room, and are supported on a special system of girders. The bunkers are grouped in the 'tween deck spaces around the boilers, and there is a saddle-back bunker over the boilers. The whole arrangement is neat and airy, with good natural lighting. Advantages claimed include a 6 to 10 per cent. increase in cubic capacity, with a 3 to 5 per cent. saving in building costs. The coal is trimmed by gravity to the firing floor, and there are no ash hoists, as the ashes can be disposed of through a gravity chute. No inconvenience is caused by the extra "wash" in the boilers, which is to be expected from their relatively high position in the ship. The boiler tubes and special baffles effectively prevent undue movement of the water in the boilers. We gathered that despite the shortening of the uptake, there is adequate draught.

The Future of Civil Aviation.

AT a meeting of the Parliamentary Air Committee on December 18th it was announced that administrative changes are to be made which will have the effect of completely separating civil from military aviation. The present Director of Civil Aviation, Lieut.-Colonel F. C. Shelmerdine, is to become Director-General of Civil Aviation and will rank equally with other members of the Air Council. The civil side will be placed under the control of the Secretary of State, the Under-Secretary and the Director-General. On the financial and all other sides civil aviation will henceforth come under this group and will no longer be the concern of the Air Council.

The Chalais-Meudon Aeroplane Testing Station.

THE difficulty of solving by theory alone the very complex problems of aerodynamics leads the constructors of aeroplanes to resort to experiments with small-scale models. With the object of increasing the accuracy of the results obtained and more nearly approaching actual facts, the French Aeronautical Department's technical services decided to construct at the Aeronautical Centre at Chalais-Meudon a testing station large enough to deal with full-sized aeroplanes.

With this object in view, the Department prepared, on the initiative of Monsieur Caquot, the General Technical Director of the Air Ministry, a scheme for a large wind tunnel and testing station. The general aerodynamic design was prepared by Monsieur Lapresle, Chief Engineer of the Aeronautical Department, who had already tried it out in the laboratory at Issy les Moulineaux, in a wind tunnel of normal dimensions, where it gave complete satisfaction. The specifications of the building were drawn up by Monsieur Aimond, Engineer of the "Ponts et Chaussées," under the direction of Monsieur Garbe, Director of the "Services des Bases." In April, 1932, tenders were invited for the construction of the wind tunnel itself. The problem was one of exceptional difficulty, and the more interesting to solve since the specification, drawn up in the widest manner, while laying down a very definite general arrangement, left to the builders complete discretion as to the methods to be adopted in the construction. As a result of the tendering, the execution of the construction was confided to a limited company, "Entreprises Limousin," whose plans and proposals were considered to be the most acceptable from both the technical and economical points of view.

We propose to confine ourselves here to giving some details of the buildings proper and to omit details of the mechanical and electrical equipment, the measuring apparatus, and all the other complicated mechanism of the station. We need only say that the aeroplane to be tested is placed between the main air inlet passage and a diffuser tunnel through which air is drawn by six fans of 28ft. diameter, each driven by a 1000 h.p. electric motor. The measuring instruments attached to the aeroplane transmit to recording apparatus the data which are being sought.

General Arrangement of the Equipment.

The testing station consists of six main units:—

(1) An inlet passage arranged to admit air, filter it, and give it its correct direction before it enters the test room proper.

(2) A test room in which the aeroplane under test and the various measuring instruments are installed.

(3) A central diffuser to regulate the flow of the air current on leaving the test room.

(4) A suction chamber of large volume which serves as a governor between the central diffuser and the fans.

(5) Six fans arranged to induce a current of air drawn from the inside and to force it to the outside of the building.

(6) Three lean-to sheds for use as workshops, built against the north, south, and west walls of the test room.

Figs. 1 and 2 show the general arrangement of this equipment, which allows of the creation of a moving air current about 313ft. long, passing in a fixed direction at speeds which may reach 112 miles an hour.

General Features of the Principal Units.

Air Inlet.—The air inlet passage has a total length of 50ft. 5in., and its transverse section is an ellipse of varying dimensions. The main horizontal axis is 81ft. 4½in. at the outer end, reduced to 52ft. 6in. at the opening into the test room. The walls are of reinforced concrete, 2¾in. thick, stiffened by ribs on the outside. This tube is supported at its outer end on a gantry, which is entirely independent of the remainder of the building, and at the outlet on the partition wall of the test room. A filter to regulate the direction of the air is provided at each of its ends. The first (Fig. 5), built at the entrance for a length of 4ft. 10¾in., consists of very thin reinforced concrete perpendicular and vertical plates inclined towards a point at the centre of the inner filter. These plates are 6ft. 6in. apart, and are bevelled on their front and rear edges so as to offer the minimum resistance to the flow of air.

The second filter, fixed at the outlet into the test room, is similar to the other, but is constructed of metal, and is so arranged as to allow the diversion of the air current by the rotation of the filter round its horizontal axis.

The Test Room.—The test room, in which the aeroplanes are tested, is a large chamber, 65ft. 7in. wide and 68ft. 10in. high, situated between the inlet conduit and the diffuser. Its total length is 225ft. 4¾in. In front of the main air conduit the room is entirely free from obstacles up to a height of 49ft. 3in.—Fig. 6, page 620. In the upper portion an observation gallery runs round the north, east, and south walls. A 5-ton travelling crane, 37ft. 8in. in span, runs the whole length of the room. At the centre, in line with the axes of the inlet conduit and the diffuser, is a massive support for the aeroplane under test. This support is embedded in the ground and its top is flush with the floor. Offices are situated on either side of the inlet conduit. To prevent the room becoming too cold when tests are not in progress, the openings of the inlet conduit and the diffuser are provided with movable shutters. The shutter for the inlet passages is a metallic curtain which opens by sliding vertically downwards into the basement. In the case of the diffuser the size of the opening being considerably larger—an ellipse of 60ft. 7½in. on its horizontal axis and 34ft. 4½in. on its vertical axis—the closure is provided by two shutters, which follow the shape of the opening and are arranged one on either side of the vertical axis of the diffuser tube. These shutters pivot, in a vertical plane, on a horizontal axis at their lower corners, opening like a fan into the basement.

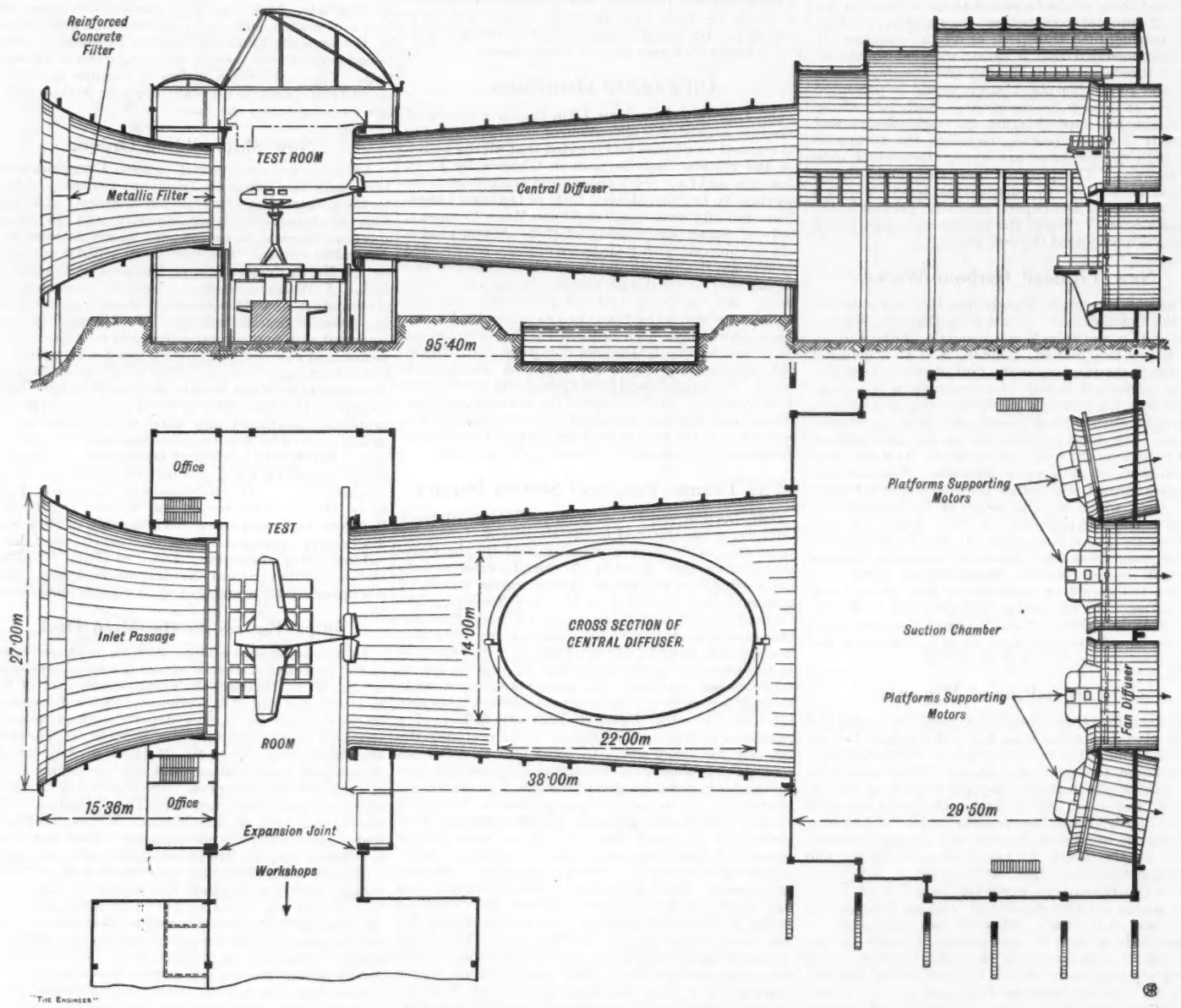

FIG. 1—PLAN AND ELEVATION OF AEROPLANE TESTING STATION

The Central Diffuser.—The diffuser—Figs. 3 and 4—is constructed as a reinforced concrete tube and has a total length of 124ft. 7in., of which 111ft. 6in. are unsupported between the point of exit from the test room and the entrance to the suction chamber. This tube has walls 2½in. thick, stiffened by ribs measuring 6½in. by 1ft. 11½in. along the outside at intervals of about 11ft. 9in. The lengths of the horizontal axes of its elliptical section vary from 59ft. to 75ft. 6in., and the vertical axes from 32ft. to 49ft. 3in. The inside of the tube is entirely free from obstructions.

Suction Chamber.—The suction chamber—Fig. 7, page 620—adjoins the diffuser tube. Its total length is 95ft., whilst its width varies from 118ft. where the diffuser enters it to 139ft. 5in. at the outside gable wall. The height of the arched roof varies in a similar manner from 74ft. to 85ft., the springing of the arch remaining at a uniform height of 46ft. above the floor level.

The Fan Diffusers.—The six fan diffusers have reinforced concrete walls, 3½in. thick, and are cylindro-conical in section, lying horizontally and having the shape of a truncated cone 3ft. 3in. long joining up to a cylindrical portion 28ft. 7½in. diameter and 16ft. 5in. long. The diffusers are fixed between two reinforced concrete partitions, 10ft. apart, one of these partitions forming the outer gable end wall of the building. Each fan diffuser has a platform to carry a motor and fan impeller. These platforms stand on brackets corbelled into the end wall.

Special Conditions Imposed upon the Builders.—These figures show the extent of the buildings and indicate the difficulties which might arise, difficulties to which certain special details inherent in the operation of the wind tunnel added. In service it was necessary to induce in the main conduit a current of air as regular as possible, at a speed which might reach 164ft. a second at the entrance to the inlet.

The specification also insisted upon the following points being adhered to rigorously by the builders :—(1) There should be no fixed obstacle throughout the whole length of the main conduits traversed by the moving air current. Consequently the interior of the inlet conduit and the diffuser, the central portion of the test room and practically the whole of the inside of the suction chamber had to be left entirely free from fixed obstacles. (2) The interior profiles of the main tunnel or conduit had to be maintained with great accuracy. The permissible variation might not exceed $^{1}/_{10}$in. in the filter, $^{4}/_{10}$in. in the inlet tube, $^{8}/_{10}$in. in the central tube or diffuser, and $^{1}/_{10}$in. in the fan diffusers. (3) Air-tightness for the whole length of the main tunnel and the parts around it was also to be assured as rigorously as possible. (4) In considering the general stability of the structure the following reductions in the inside air pressure had to be allowed for :—Inlet conduit, a uniformly distributed reduction below atmospheric pressure varying progressively from zero at the opening to 0·232 lb. per square inch at the outlet into the test room; test room and its neighbourhood, a uniform reduction of 0·232 lb. per square inch; central tunnel or diffuser, a reduction in pressure varying from 0·232 lb. per square inch to 0·116 lb. per square inch; suction chamber, a uniform reduction of 0·116 lb. per square inch.

These numerous conditions led, on the one hand, to a search for the simplest shapes which would assure the accuracy required and at the same time realise as homogeneous and monolithic a structure as possible. This double result was obtained by the use of reinforced concrete, not only for the framework generally, but also for the partition walls, which were cast in place, thus contributing, in conjunction with the other portions of the framework, to the general stability of the structure.

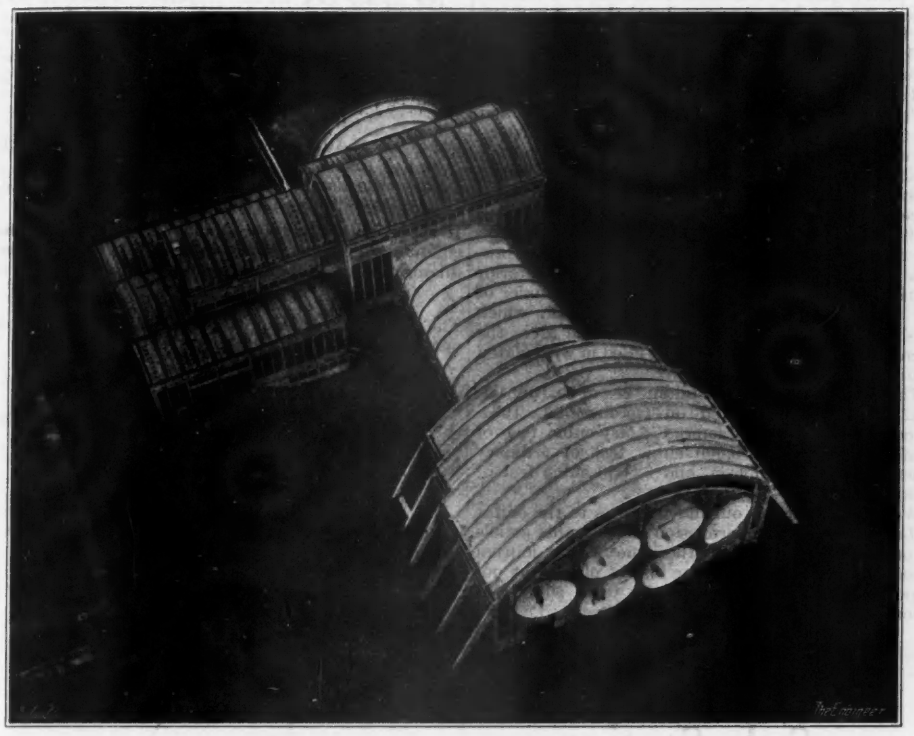

FIG. 2—AERIAL VIEW OF TESTING STATION

MAIN DIFFUSER AND INLET CONDUIT.

From the purely constructional point of view the problem was the same for both these units. The main diffuser, however, was the most difficult part by reason of its length, which is round about 124ft. 6in., and of which 111ft. 6in. are entirely unsupported. In the case of both units it was necessary to construct economically and yet with great accuracy a hollow elliptical tunnel of exceptional dimensions.

When a sectional drawing of the enormous ring was made attention was at once drawn to the great transverse stresses arising from its very dimensions. It was held to be useless to seek a solution by the introduction of intermediate supports of any kind. It therefore became necessary to reduce the various thicknesses to a minimum, since the bending moments increase very rapidly with even slight increases in the weight per square foot. In view of the annular section the transmission of the shearing stresses was by far the most difficult feature of the design.

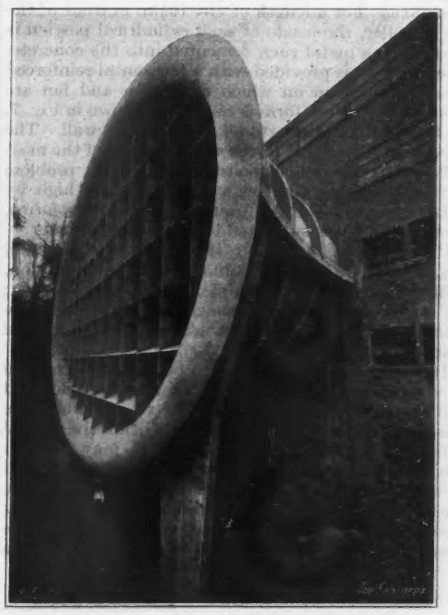

FIG. 5—FILTER AT ENTRANCE TO INLET PASSAGE

SUCTION CHAMBER AND FAN DIFFUSERS.

The suction chamber is formed of three connected rings, each of the same shape and cast in the same "centering," the size of which necessarily increases, both in height and in width from the north wall towards the southern one. Each of the six roof supports—see Fig. 2—consists of a vertical column and a buttress joined together at their upper ends. Under the thrust of the roof the buttress is subjected to compression while the vertical column is in tension, the latter component being cancelled out by the walls being arranged as counterweights. To effect this end the reinforced concrete walls, 4in. thick, were extended into the ground and a shoe or base provided large enough to allow for an adequate weight of soil to rest upon it. On account of the nature of the soil it appeared wise to allow it to take only vertical

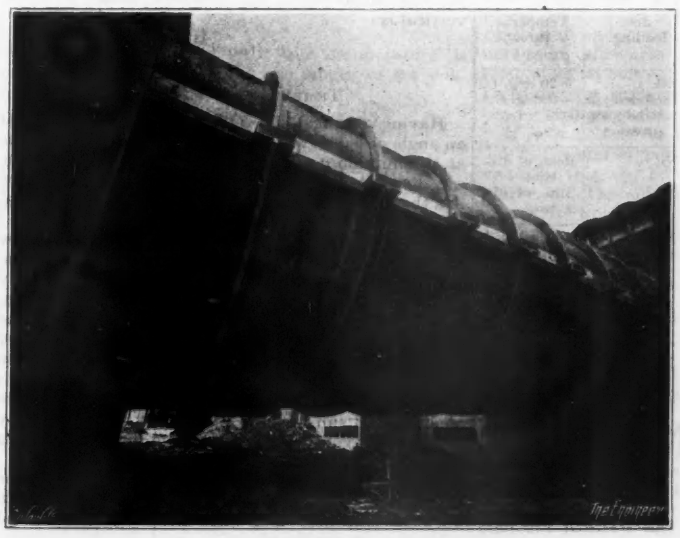

FIG. 3—EXTERIOR OF DIFFUSER

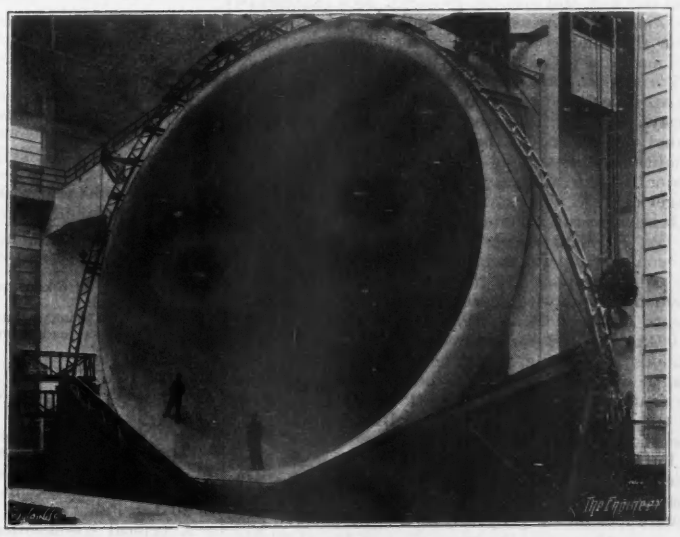

FIG. 4—INLET TO DIFFUSER

thrusts. To accomplish this object the horizontal resultant of the thrust on the buttresses is taken up by the tie rods placed beneath the floor level. The lifting tackle installed in the suction chamber to enable the motors and fan impellers to be placed in position consists of four mono-rails fixed in the arch of the roof with carriages for blocks capable of lifting 10 tons. Access to these appliances is obtained from four balconies, also suspended from the roof, and staircases with metal treads attached to the south wall.

The six fan diffusers, as already stated, are built into the south wall of the suction chamber. Each consists of a casing, 19ft. 7in. long, constructed of reinforced concrete, 3½in. thick, the inside being in the form of a truncated cone connecting with a cylindrical portion, 28ft. 7½in. in diameter on the same axis. For a length of 4ft. 10½in. in front of the fan impeller, the inside of each cylindrical portion is faced with a metal ring, cemented into the concrete. Each diffuser is provided with a horizontal reinforced concrete platform on which the motor and fan are mounted. The platform is carried, as shown in Fig. 7, on two inclined supports let into the end wall. The execution of this part of the work was one of the most difficult in the whole construction. The problem necessitated mounting on a wall 85ft. 4in. high by 141ft. long, the six diffusers and their platforms, each of which was subjected to the following loads :—(1) Fixed load, 74,800 lb.; (2) weight of motor and fan, 59,400 lb.; (3) horizontal axial thrust of fan, 12,540 lb.; (4) motor couple, 18,000 pounds-feet ; (5) in the event of the breakage of an impeller blade a force of 165,000 lb. would take effect in a vertical plane in any direction.

It was necessary therefore to be extremely careful of vibrations. To that end the forces were doubled and the maximum strength of the various materials was taken as being very considerably below the normal figure. The fans, it should be noted, may have to run either individually, simultaneously, or grouped in any arrangement, with the result that a large number of different unfavourable conditions may arise. Given the dimensions of the end wall of the suction chamber and those of the diffusers and the relative positions of the units, there remained very little room in which to place the framework required to support the stresses. Further, it was necessary to balance the twisting moments of the overhung platforms which for the whole six is 3,456,000 pounds-feet—a considerable figure. For this reason, and in view of the accuracy demanded by the specification, it was essential to find a method of construction which was simple and easy to carry into effect, any design involving the use of pillars or girders with horizontal, inclined or diagonal struts was impracticable. After much consideration an extremely simple solution was adopted. This solution involved the use of two vertical and parallel partitions in reinforced concrete, without ribbing, placed 10ft. apart. Into these partitions the fan diffusers and the platform supports were to be built. The twisting moments are nullified by the exterior partition which forms the end wall of the suction chamber.

The horizontal platforms carrying the motors and the fan impellers rest on two inclined struts converging towards their upper ends. These struts are built in at their bases and connect the two partitions to which they transmit the stresses. The horizontal forces arising from the thrust of the fans are absorbed by five thin vertical partitions and stiffeners between the two main walls. With a view to reducing vibration in the building, as much as possible, the interior partition is entirely independent of the remainder of the structure, as is also the exterior wall, which finishes 5ft. 10½in. below the soffit of the arch, the opening above the partition being filled in with glazed frames.

The work of erecting the building began on July 1st, 1932, and was completed on October 1st, 1934. It entailed the use of some 176,500 cubic feet of reinforced concrete, 70,600 cubic feet of ordinary concrete, 700 tons of iron, and 38,830 cubic feet of wood.

We have to express our indebtedness to the editor of *Le Génie Civil* for permission to base this article on one which appeared in the issue of that journal dated November 3rd, and for kindly placing at our disposal the original photographs from which the accompanying engravings have been prepared.

Bus-Bars for Outdoor Sub-Stations.

No. III.

By A. M SPRUCE, A.A.I.E.E.

(Concluded from page 600, December 14th.)

ICE LOADING AND GENERAL SPECIFICATIONS.

WHEN designing the structural members that support strained bus-bars, it is necessary to consider the maximum forces that can possibly occur at one time. This condition exists when the wind velocity is greatest and the temperature lowest with an ice-loaded conductor. The effect of accumulation of ice and snow on a conductor is to increase the dead load per foot and also the projected area exposed to the wind. An increasing wind will tend to remove ice from the conductors, but a decreasing temperature will make the ice adhere more firmly to them.

For the purposes of calculating the wind pressure on an ice-covered conductor and the ice weight it is always assumed that the ice forms concentrically round the outside of the conductor. Under actual conditions, however, the shape is more oval, with the major axis in a vertical plane, thus presenting a larger exposed wind surface.

It is interesting to note that from observations made by W. R. King during a sleet storm at Portland, Oregon, the rule was deduced that the diameter of the ice equalled about 1·8 times the fourth root of the diameter of the wire, measured in inches.[7] Measurements made by R. R. Ryan[8] on a telephone wire 0·094in. in diameter showed an elliptical but continuous ice coating, with icicles varying greatly in length and frequency, there being apparently more on taut conductors than on slack ones. The spacing of the larger icicles ranged from 1in. to 4in. apart ; the shorter icicles were practically continuous.

For this country it has been specified by the Electricity Commissioners, as set out in El. C. 53, 1928, that the horizontal wind pressure is to be 8 lb. per square foot on the projected area of ice-covered conductor with a radial thickness of ice of ⅜in. at 22 deg. Fah. The weight of ice coating is calculated on a basis of 57 lb. per cubic foot. This covers the worst case for pure ice, as usually the accumulation is a mixture of ice and snow, which weighs much less than ice.

In countries where the minimum temperature reached is below 22 deg. Fah. a correspondingly greater radial thickness of ice may be specified, and/or a higher horizontal wind pressure. Even for the same country two or more different loading conditions may exist, depending upon the locality in which the stations are erected. In America, for instance, three loading conditions are in use, corresponding to light, medium, and heavy loading districts, with specifications classified as A, B, and C. The radial ice thickness is zero for Class A, ½in. for Class B, and ¾in. for Class C, with conductor wind pressures of 15 lb., 8 lb., and 11 lb. per square foot respectively.

Table V gives the loading conditions in operation at the present time in certain countries, as specified by the various Government Departments or large power companies interested in such regulations.

TABLE V.—*Conductor Loading Conditions.*

Country.	Wind pressure on projected area of conductors.	Ice loading.	Temperature.
Germany ..	(*a*) Nil (*b*) (190+50 *d*) gms. per m., where *d*=conductor dia. in mm.	Nil Included in wind expression	−20 deg. C. −5 deg. C.
France ..	(*a*) 72 kilos. per sq. m. (*b*) 18 kilos. per sq. m.	Nil Nil	Mean of district Min. of district
Australia ..	15 lb. per sq. ft. 10 lb. per sq. ft.	Nil Nil	40 deg. F. 20 deg. F.
Norway ..	(*a*) 62·5 kilos. per sq. m. (*b*) Wind included in ice load expression	Nil (200+30 *d*) gms. per m., where *d* = cond. dia. in mm.	25 deg. C. −25 deg. C.

For New Zealand two specifications exist, the first (*a*) specifies a wind pressure of 18 lb. per square foot, ice nil, and 20 deg. Fah. temperature ; and (*b*) 8 lb. per square foot wind, ½in. radial ice, and a temperature of 20 deg. Fah.

A typical specification for the strained bus-bars used on the Waitaki Power Development, 50-kV stations, as affecting the supporting structure designs, is given here as an extract from the main specification issued by the Public Works Department of New Zealand.

Bus-bars and Connections.—The strain bus-bars shall consist of 19/·101 H.D. bare copper cable, and the connections shall be of solid drawn copper tube with a net section of not less than 0·15 square inch. All necessary terminals and mechanical clamp connectors shall be supplied. No purely sweated joints shall be used. The strain insulators shall be connected to the structures by means of threaded coupling rods, with lock nuts to facilitate taking up the slack in the bus-bars when erecting.

Loading.—The main structures shall be designed to carry the following transverse loads in addition to the vertical loading due to the supported apparatus :—

(*a*) The stresses due to supporting a tensile load in each line conductor of 4000 lb. at an angle of 60 deg. to 120 deg.

(*b*) The stresses due to supporting a tensile load in each bus-bar of 1500 lb.

(*c*) A transverse force due to wind pressure on all attached lines of 300 lb. per conductor.

(*d*) A wind pressure of 18 lb. per square foot on the projected area of cylindrical surfaces and 30 lb. per square foot on all supported apparatus and on 1½ times the projected areas of girders and towers.

The diameter of an ice-coated conductor used in calculating the projected area for wind pressure is given by

$$D = d + 2r \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where D = the diameter of the ice-coated conductor in inches,
d = the diameter of the conductor alone in inches,
r = specified radial thickness of ice in inches.

If *w* equals the weight in pounds per foot run of the conductor alone, then the weight per foot run of conductor plus ice, in pounds, acting in a vertical plane is

$$V = w + 1{\cdot}25\,(d\,r + r^2) \quad . \quad . \quad . \quad . \quad (2)$$

The horizontal wind force in pounds per foot run of conductor will be given by

$$H = \frac{(d+2r)}{12} \times \text{specified wind pressure} \quad . \quad (3)$$

Fig. 5 shows these two components acting at right

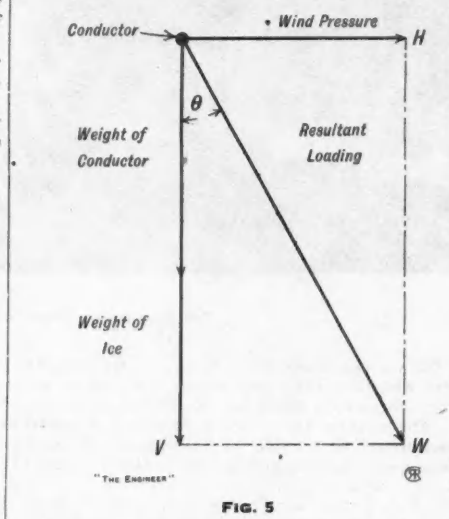

FIG. 5

angles to each other, so that the resultant total loading W lb. is

$$W = \sqrt{V^2 + H^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

and the angle which the resultant makes with the vertical is

$$\theta = \tan^{-1}\frac{H}{V}.$$

TEMPERATURE EFFECTS.

Having obtained the total load of W lb. acting at an angle of θ deg. to the vertical, the sag in this plane at the minimum temperature can be obtained. The sag, however, under these conditions will usually be less than the sag at the maximum operating temperature.

For any particular locality it is essential to know the maximum temperature the outdoor station bus-bars can reach. The sag at this temperature generally determines the conductor clearances. The temperature of the conductors may or may not be at the same temperature as the surrounding air, but to consider the worst case the maximum temperature should be taken. It is not infrequent to obtain conductor temperatures of about 180 deg. Fah. under the influence of a tropical sun ; where this occurs during the day followed by very cold nights, large variations of sag will result.

The following table gives a rough indication of the fluctuation of air temperatures during the year in various latitudes, and the mean maximum and minimum at certain places.

	Deg. Fah.
Eastern Europe	140–170
Central Europe	114–130
Western Europe	86–104
The sub-tropics	68–104
The tropics	50– 86

District.	Air temperature in deg. Fah. Mean maximum.	Mean minimum.
Pernambuco	82	75
Rio de Janeiro	78	67
Calcutta	86	65
Peking	79	24
Charbin	72	−2
Berlin	65	31

For Great Britain the maximum operating temperature specified by the Electricity Commissioners

is 122 deg. Fah., and for station clearances the sag at this temperature should be known. At 122 deg. Fah. the air is assumed to be still, so that the sag, now due to the deadweight of the conductor only, but with an increased conductor length, will be in a vertical plane. For the conductor clearances required on outdoor sub-stations reference should be made to the recently revised British Standard Specification No. 162—1934, and also No. 159—1932 on bus-bars.

SAG AND TENSION CALCULATIONS.

Various formulæ, equations and graphical methods are in use for expressing the relation between sag, tension, span, length of conductor, and change in length of conductor (stressed and unstressed) due to temperature variations. Probably the most rapid formulæ to apply are the equations based on the parabolic curve. These are more simple than the catenary functions and very easily applied to any specific case. For sub-station work it is not essential to be exact when finding the tension or sag at any particular temperature, and, since the end supporting insulators affect the results, the parabolic functions are sufficiently accurate.

In order to present the sag and tension formulæ in a logical way so that they may be readily applied, a further list of symbols is necessary, as follows :—

l = length of span in feet.
L = actual length of conductor at datum temperature with maximum loading, in feet.
L_u = Length of unstressed conductor at datum temperature (zero stress), in feet.
L_{t_2} = Length of unstressed conductor at temperature t_2, in feet.
t_1 = minimum datum temperature in deg. Fah.
t_2 = temperature at which S_2 is measured, deg. Fah.
t = temperature rise in deg. Fah. $= t_2 - t_1$.
W = resultant loading in pounds per foot run under worst conditions, which includes wind pressure and ice loading (if any).
T = tension of conductor under worst loading conditions at t_1, in pounds (*i.e.*, breaking load divided by factor of safety).
T_2 = tension of conductor at temperature t_2, in pounds.
S = sag under worst loading conditions at temperature t_1, in feet.
S_2 = sag without wind and ice at temperature t_2, in feet.
E = modulus of elasticity in pounds per square inch.
c = coefficient of linear expansion per deg. Fah.
A = conductor cross-sectional area in square inches.
e = elongation due to stress, in feet.

The sag under the worst conditions of loading with a maximum allowable tension T, is found from the general parabolic formula

$$S = \frac{W l^2}{8 T} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

The corresponding length of conductor, *i.e.*, the length of the parabolic curve, is

$$L = l + \frac{8 S^2}{3 l} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

If the tension be removed from the conductor, the unstressed length is given by the equation

$$L_u = \frac{L}{1 + \frac{T}{E A}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

Under these conditions if the temperature is assumed to rise t deg. Fah., the length of the conductor in the span is found from

$$L_{t_2} = L_u (1 + c\,t) \quad . \quad . \quad . \quad . \quad . \quad (8)$$

Up to the elastic limit of metals, both stress and strain are proportional to the load, and the ratio stress to strain is constant and equal to the modulus of elasticity, *i.e.*,

$$E = \frac{T_2}{e} \Big/ \frac{A}{L_{t_2}} = \frac{T_2 L_{t_2}}{A\,e} \quad . \quad . \quad . \quad . \quad . \quad (9)$$

At the higher temperature t_2 no wind or other external loads exist, so that the sag will be due to its dead load w only. Therefore we have

$$S_2 = \frac{w l^2}{8 T_2} \text{ or } T_2 = \frac{w l^2}{8 S_2} \quad . \quad . \quad . \quad . \quad . \quad (10)$$

From equation (9) the elongation equals

$$e = \frac{T_2 L_{t_2}}{E A} = \frac{L_{t_2} \left(\frac{w l^2}{8 S_2} \right)}{E A} = \frac{L_{t_2} w l^2}{8 S_2 E A} \quad . \quad . \quad (11)$$

The total length of the conductor is given by

$$L_{t_2} + \frac{L_{t_2} w l^2}{8 S_2 E A} \quad . \quad . \quad . \quad . \quad . \quad (12)$$

Substitute S_2 for S in equation (6), then this becomes equal to equation (12), so that

$$l + \frac{8 S_2^2}{3 l} = L_{t_2} \left(1 + \frac{w l^2}{8 S_2 E A} \right) \quad . \quad . \quad (13)$$

Equation (13) may be transposed into a cubic equation, from which S_2 may be found, all other quantities being known. Therefore, we have

$$S_2^3 - \frac{3 l}{8} (L_{t_2} - l) S_2 = \frac{3 L_{t_2} l^3 w}{64 E A} \quad . \quad . \quad . \quad (14)$$

This relationship expresses the sag in feet at any temperature above datum (in still air), due to the weight of the conductor only. The determination of S_2 from the last equation is easily accomplished from a trial and error method by assuming a particular value for S_2. Substitute this value in the equation and note whether it is too small or too large. After two or three trials in this manner the correct value will be found.

The application of the preceding formulæ is best seen by a typical example. Assume a stranded copper bus-bar of 0·15 square inch sectional area subjected to the standard British conditions of loading, and arranged so that under the worst conditions of loading the maximum tension does not exceed 2000 lb. Table III (*ante*) gives a list of standard copper conductors commonly used for outdoor sub-station bus-bars. From this table the weight per foot run for a 0·15 square inch cable is 0·592 lb., and the diameter 0·504in. It is required to find the sag and corresponding tension at the maximum operating temperature of 122 deg. Fah.; assume the span to be 50ft.

From equation (2)

$$V = 0{\cdot}592 + 1{\cdot}25\,(0{\cdot}504 \times 0{\cdot}375 + 0{\cdot}375^2)$$
$$1{\cdot}004 \text{ lb. per foot run.}$$

From equation (3)

$$H = (0{\cdot}504 + 2 \times 0{\cdot}375) \times \frac{8}{12}$$
$$0{\cdot}835 \text{ lb. per foot run.}$$

From equation (4)

$$W = \sqrt{1{\cdot}004^2 + 0{\cdot}835^2} = 1{\cdot}3 \text{ lb. per foot run.}$$

From equation (5)

$$S = \frac{1{\cdot}3 \times 50^2}{8 \times 2000} = 0{\cdot}197\text{ft.}$$

From equation (6)

$$L = 50 + \frac{8 \times 0{\cdot}197^2}{3 \times 50} = 50{\cdot}00207\text{ft.}$$

From equation (7)

$$L_u = \frac{50{\cdot}00207}{1 + \frac{2000}{18 \times 10^6 \times 0{\cdot}15}} = 49{\cdot}965\text{ft.}$$

From equation (8)

$$L_{t_2} = 49{\cdot}965\,(1 + 9{\cdot}22 \times 10^{-6} \times 100) = 50{\cdot}011\text{ft.}$$

From equation (14)

$$S_2^3 - \frac{3}{8} \times 50 \times 0{\cdot}011 \times S_2 = \frac{3 \times 50{\cdot}011 \times 50^3 \times 0{\cdot}592}{64 \times 18 \times 10^6 \times 0{\cdot}15}$$

or

$$S_2^3 - 0{\cdot}206\,S_2 = 0{\cdot}0573$$

Therefore

$$S_2 = 0{\cdot}555\text{ft.} = 6{\cdot}65\text{in.}$$

To find T_2, the tension in the cable at 122 deg. Fah., substitute the value found for S_2 in equation (10). Thus

$$T_2 = \frac{0{\cdot}592 \times 50^2}{8 \times 0{\cdot}555} = 333 \text{ lb.}$$

The values S_2 and T_2 here found are for an operating temperature of 122 deg. Fah. (*i.e.*, a rise of 100 deg. Fah.); by adjusting the value of the temperature rise t in equation (8), the sag and tension may be found for any other operating temperature above datum. Consequently, with any particular span length of bus-bar the sag and tension may be obtained for the complete working temperature range, and curves plotted with temperature as abscissæ and sag and tension as ordinates. From these curves the erection of the bus-bars can be carried out at any air temperature, and under the worst loading conditions the maximum allowable tension will not be exceeded. Such erection curves are tedious to calculate, but are necessary for the erection department to carry out proper stringing of the bus-bars.

If it is desired to take into account the extra sag due to the end supporting insulators, an approximate value for this may be obtained from the curves given in Fig. 6. The curves are drawn for various values of bus-bar working tensions from 1000 lb. to 3000 lb. In the preceding typical example, if it is assumed that there are eight insulator units, then the extra sag to be added for 2000 lb. tension is approximately 1·3in. The total sag is, therefore, about 8in.

CONCLUSION.

It is interesting to compare the various bus-bar arrangements as developed by power companies and engineers to suit the local conditions of outdoor station lay-out. They are, of course, too numerous to be mentioned here, but reference may be made to publications containing miscellaneous station arrangements. The English grid stations have been described from time to time in the Press, and interesting collections of photographs given in the annual reports of the Central Electricity Board. Outline drawings of American designs from 11 kV up to 220 kV are to be found in the N.E.L.A. Report of the Apparatus Committee on "Outdoor Sub-station Design."

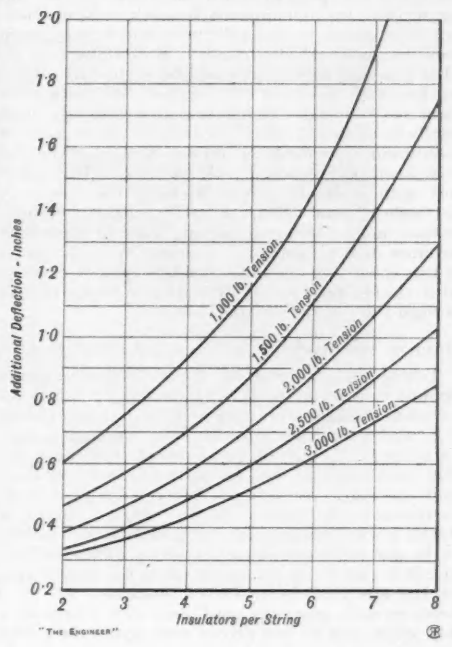

FIG. 6

Such an article as this must necessarily be abbreviated in many places, and although certain essential tables have been compiled and included, many others are necessary for ready reference. The following bibliography has, consequently, been included to furnish a few texts and articles bearing on the subject of strained electrical connections, or connections generally, for those who wish to investigate any particular phase more thoroughly.

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Machine Tools from the Works Manager's Point of View.

By JOHN HOLLOWAY, M.I. Mech. E.

No. IV.

(*Concluded from page 587, December 14th.*)

TO transmit power by mechanical means to the more distant points of large machines, particularly heavy lathes, with long beds, is generally somewhat cumbrous, especially in cases where the lathe is designed to take, say, 30ft. to 40ft. between centres for turning such work as heavy rolls, turbine rotors, tunnel shafting, &c. To overcome the difficulty of transmission in these cases, it is now usual to employ multiple electric motor drives, the auxiliary motors being placed at convenient points, and sometimes only used for the quick traverse of saddle and slides, while push-button starters are placed in convenient positions. This method has the advantage of cutting out much of the gearing that would otherwise be necessary, but it has the disadvantage of increasing the number of electric motors, and necessitates in some cases the provision of electric conductors along the whole length of the lathe bed.

On machines of the size we are considering, the objection to the dual drive is not so pronounced as in the case of smaller machines, and it is quite possible that the best arrangement would be electric-mechanical power for the main drive, using hydraulic power for the feeds and quick motions to saddles and slides.

This could be done without sensibly increasing the power units, which would be an advantage many works managers would appreciate. But in applying hydraulic power for this purpose, care has to be taken to prevent other disabilities occurring, such, for instance, as inaccessibility and excessive floor space.

With other types of heavy machine tools, such as planers, slotters, and shapers, the electric-mechanical drive undoubtedly holds the field. The examples of these types represented at the recent Machine Tool Exhibition showed the sound lines on which these machines have been developed to meet present-day demands for high-speed cutting and quick return. Some of the demonstrations given bordered on the spectacular, but the speed at which machines could be run and reversed without appreciable shock to the mechanism is evidence of the skill with which they have been designed and constructed. It is difficult to see what practical advantage could be secured by adopting hydraulic power on this class of tool, either for main drive or feeds. A higher power efficiency could hardly be expected, while it is doubtful that control of speeds and feeds would be improved, or, that the cost of upkeep and repairs would be less. The initial cost with hydraulic power would almost certainly be higher than with electric-mechanical power, so that unless there is something more to come than we know of at present to recommend hydraulic power in this sphere, the purchaser of this class of machine with electric-mechanical drive, has nothing to fear in regard to future developments.

Making the Best Use of Hydraulic Power.

Taking an all-round survey of hydraulic power applied to machine tools, we have indicated to some extent in this and in previous articles the field in which it is, and in which it may be, used with advantage. In its present stage of development it is inevitable that each machine shall be made as a self-contained unit, having its own motor-driven pump, and outfit to transmit the power. At the moment this is no doubt a wise arrangement, as it allows the machine to be placed in any desired position in the factory, and it is just as easily connected to the power main as the straight electric-driven machine, but as it becomes more generally used, and more machines in any given factory are driven with hydraulic power, the advantages offered by the central hydraulic power station are sure to be recognised, and machines will be supplied with power from pipe lines, instead of carrying individual pumps. The power efficiency will consequently be increased, and the cost of upkeep reduced. This method has already been used with success, and will no doubt gain in favour as the number of machines requiring hydraulic supply increases. The system is simplicity itself—a supply and return pipe line between the machines and the pumping station. The other advantages gained with this system are that changes in temperature affecting viscosity can more easily be controlled, while air in the fluid can be extracted and prevented from being pumped into the power feed line. By these means the hydraulic power supply can be made consistent throughout the whole working day.

In any works or factory where the use of hydraulic power is on a big enough scale to warrant the instalment of a central pumping plant, to supply power for machine tools from pipe lines, it would be a wise precaution to have the pumping plant of sufficient capacity to leave a good margin of power that could be applied to lifting and moving apparatus, for handling the work going on the heavier class of machine.

Lifting and Moving Appliances.

We have already dealt with the importance of lifting appliances in a previous article, but would emphasise the point again here. With an abundant supply of hydraulic power in the machine shop, a very ready means will exist for handling heavy pieces of work, and if properly applied to the purpose it will doubtless further the interest in this form of power, and greatly increase its usefulness. We commend it to the attention of the hydraulic engineer, who, having already imposed his skill on machine tool design, has here a great opportunity to go still further, and supply a very real need. Even at the risk of repeating ourselves, we say that in the same ratio as the cutting time of machine tools has been reduced, so has the need for lifting and handling facilities increased. We will go further and say—from the works manager's and production engineer's point of view—that to be asked to take the responsibility of installing a modern heavy high-speed machine tool with all its improvements to reduce the machining time of heavy or medium heavy parts, and then to risk losing all the time saved, because of the lack of handling appliances, is a very unsound proposition meriting not the slightest consideration. Many machines can only be considered complete when they have facilities for expeditiously handling their own output, and this is true whatever kind of power is used, whether mechanical, electric, or hydraulic.

An Illustration.—One of the most interesting demonstrations seen at the Olympia Exhibition was that given on a heavy tramway wheel lathe—this will serve to illustrate the feasability of our demand for handling facilities on machine tools. This lathe has two headstocks, both of which are arranged to traverse so as to allow for easy loading of the wheels to be turned. The slide rests are also fitted with quick power traverse, to bring the tools right up to the point of cutting; but the time-saving apparatus does not stop there, as it does in most other machines. There is a power-operated jack for lifting the wheels into position for turning, and for lowering them on to rails to be run out clear of the machine after the turning operation is completed. Here, then, is a real time and labour-saving tool; puts its own work in, machines it, then takes it out again, and repeats the cycle of operations. Is there any legitimate reason why similar handling facilities should not be extended to other types of machines? One may occasionally see compressed air jacks fitted over machines in shops where compressed air supply is available; but what we have in mind is handling appliances integral with the machines and operated by the same source of power as the machine itself.

Improved Lubrication of Machines.

A very noticeable improvement in practically all the machines exhibited was the lubricating methods adopted. Many will remember the old days when the oiling of the machine was left entirely in the hands of the turner and machinist, who would occasionally pour a few drops of oil into a small hole, thoughtfully provided by the maker, and then trust to providence to keep the machine running smoothly. Many will also remember how often it became necessary to call in the millwright to assist providence—in this matter at least—to get the wheels to go round at all; at such times the language of the foreman and millwright was not always what is sometimes called parliamentary, and no wonder. But all that has changed, partly, no doubt, owing to the higher speeds at which machines are now run. All the main points now have automatic feeds, and there are a number of well-designed forced-feed lubricators now available for the purpose, while the introduction of oil-loaded roller and ball bearing for the main spindles look after those parts admirably. On some machines a few points are still left to the care of the operator, but on the whole lubricating is well done, and will doubtless add to the life of the tool, as well as relieving those responsible of anxiety on that score. The importance of positive lubrication was recognised by engine builders long ago, and it is good to see that machine tool builders have now given the matter adequate attention.

Flexible Drive.

Another noticeable feature worthy of more than passing interest is the almost universal adoption of flexible drives from motor to main shafts and spindles. The multi-Vee grooved pulley and flat Vee belt have been fitted to a very large number of machine tools of various types. The nature of this drive permits its use for quite short centres between the driving and driven pulleys. It also allows for a very substantial ratio of speed variation. When running at high speeds it is smooth and quiet, while there appears to be an almost entire absence of slip; the idea of the Vee-pulley drive is, of course, by no means new, neither, for that matter, is the multi-groove pulley. The element of novelty is probably to be found in the belt itself, or, rather, in the material from which it is made, for uniformity of texture and non-stretching qualities are essential to ensure that all belts shall carry the same load. The popularity of this drive on machine tools is evidence of its success in this respect.

Future Developments.

In what direction future developments will tend is difficult to tell and unwise to attempt to forecast, but it is safe to say that manufacturers of machines are fully alive to the great possibilities that exist. Some machine tool makers have set their faces firmly against the use of hydraulic power for any purpose on their machines, while others are open to take whatever advantage this power offers. As we have already seen, hydraulic power has proved very suitable for some classes of tools, and one may readily infer that for certain work it has come to stay; but it would be folly to say that it is good for all purposes, and to attempt to do too much with it in its present stage is to invite failure. If in due course it is found possible to simplify the construction of the machine, increase the efficiency, or lower the cost by using hydraulic power, then users of the tools will not only welcome, but demand it; otherwise, it is unlikely that much further progress with the power will be made.

Taking an all-round view of machine tool design, many practical users are unquestionably of opinion that owing to the elaborate and what may be called tricky nature of some of the mechanism, partial failures and breakdown are likely to be more frequent than with the plainer type of tool. Should this prove to be the case, it will become necessary to revert to a less elaborate machine, and by doing so it is quite possible that a higher all-round efficiency will be reached and maintained over a long period.

We have consistently stressed the demand for "overall" efficiency to be taken into account when comparing the performance of machine tools, and have shown that it is the most important factor to be considered when selecting new plant. But when examining machines at exhibitions, such as that recently held, it is difficult to arrive at a true idea of what the efficiency, in practice, is likely to be, because with the exception of a few cases the machines, though coupled up with power and running, were only doing what may be called imaginary work; that is to say, they were not producing actual parts. For instance, to see a drilling machine drilling holes at random through blocks of cast iron, or a lathe turning straight pieces of heavy steel, or, again, a planer cutting a slab of metal, is likely to be quite misleading from the efficiency point of view. Machine tool exhibitions could be made so much more useful and interesting if more of the machines were operating on known parts, and they would be still more useful if a given piece of work were put through all the necessary operations in proper sequence.

It is admitted that in the last Exhibition there were a few cases where small parts of motor engines were dealt with in the way we have suggested, and in these cases there was convincing proof of the efficiency claimed. Another case comes to mind of a heavy boring and facing machine on which a bit of boring and facing was being done on a locomotive cylinder casting in a rather tentative way. The only point a demonstration of this sort proved was the fact that the machine was big enough to take that particular job. It hardly seems necessary to have an exhibition to prove that much. But how much better would it have been as a demonstration, and how little more would it have cost, to have put the cylinder through all its operations in sequence. The opportunity would have been there to show how the casting would be handled, and passed from one machine to the other for succeeding operations; while the overall time taken on the work would be shown. That would have been a real demonstration well worth seeing and studying. This is but an instance of the way in which machine tool exhibitions could be and should be made the most interesting and useful of all exhibitions.

The machines were there, probably the finest collection ever put under one roof. All the most advanced examples of what machine tools can be were to be seen in every variety. As a show it was superb, but as far as demonstration was concerned, it was not strong, or as useful as it might have been. And, after all, as we have indicated, the purchaser of machine tools and the works manager who is trusted to make the best selection of machines for the work in hand is not likely to be so much influenced by a show as he is by a concrete demonstration of what the machine will do when installed in his works.

The New Fulham Power Station.

No. II.

(Concluded from page 599, December 14th.)

THE two 75,000-kVA Metropolitan-Vickers turbo-generator sets now being installed in the station have been constructed in accordance with the makers' standard practice for large two-cylinder impulse machines, and do not present unusual features. They are designed for an initial steam pressure of 600 lb. per square inch and a total steam temperature of 825 deg. Fah., which will be maintained constant by the automatic control system described. In the high-pressure cylinder a velocity compounded stage is followed by twenty-one single-impulse stages, whilst in the low-pressure cylinder thirteen impulse stages are followed by a duplex multi-exhaust. On each side of the high-pressure cylinder there is an emergency stop valve and three admission valves arranged to work in parallel, so that corresponding valves operate together in pairs. Each group is controlled by its own governor relay pilot valve, and apart from the common governor the two relay systems are entirely separate. Spring loading above the steam valve operating power pistons avoids the use of oil pressure to close the valves. When a sudden reduction of load calls for the rapid closing of the steam valves, oil is rapidly forced by the spring loading into a release chamber on each power cylinder, an arrangement that gives a quicker closing action than is obtainable when oil under pressure is employed instead of springs. For loads up to 60 per cent. M.C.R. full belt steam admission to the velocity stage is controlled by the first pair of governor valves; for loads between 60 and 80 per cent. it is by-passed by the second pair of governor valves to the first impulse stage; while for loads between 80 per cent. M.C.R. up to the full M.C.R. load of 60,000 kW, the third

pair of governor valves by-passes the velocity stage and the first four impulse stages.

The top and bottom sections of the high-pressure cylinder are formed of two castings; the lower one having branches at the exhaust end for conveying steam through coupling pipes just above the floor level to the low-pressure cylinder. All the diaphragms in the high-pressure cylinder are built up diaphragms, consisting of steel plate centres with independently machined nickel steel nozzles riveted to them, and in accordance with the makers' standard practice for large machines they have a three-point support, which enables the diaphragms to expand concentrically with the shaft and to maintain the diaphragm joint in a steam-tight condition. The inner peripheries of the diaphragms surrounding the shaft have "M.V." comb type packing rings, similar to the units comprising the gland at the exhaust end of the high-pressure cylinder. Apart from the moving blades of the velocity compounded stage, which are machined solid with their packers from 5 per cent. nickel steel, all the moving blades of the high-pressure cylinder are composed of rolled section stainless steel with separate packers, the blades and packers having T-shaped roots. At the inlet end of the high-pressure cylinder an "M.V." radial clearance comb type gland is used. It is formed of steel segment rings, each providing with the corresponding portion on the rotor a number of throttling points. Each ring is backed by a series of flat springs, while other flat springs support the housing containing three or four rings. Both the individual rings and the housings themselves are capable of lateral displacement in the event of accidental contact, while maintaining the original formation of the gland. In the event of rubbing occurring, the expansion by heat of the horizontal gland sleeve strips in contact causes the clearance to be increased and the gland resumes its normal clearance when the cause of the rubbing is removed. The gland comprises two main sections which provide seventy-two throttling points. At the exhaust end of the high-pressure cylinder the gland is designed on the same principle as that at the other end, but somewhat different throttling ring strips are adopted to allow for expansion of the rotor relative to the casing.

Apart from the diaphragm of the final stage in the low-pressure cylinder, all the diaphragms are composed of cast iron with cast-in steel blades, the final stage diaphragm being of welded plate construction. The first seven wheels have stainless steel rolled section blades with T roots and separate packers, while the remaining blades are of the straddle type machined solid with their distance pieces and riveted to the discs. At the inlet end of the low-pressure cylinder the gland is of the same type as that at the inlet end of the high-pressure cylinder, but has fewer segments, whilst the gland at the exhaust end is a water-sealed gland supplemented by simple labyrinth rings. Thrust blocks of the latest Michel type are located at the inlet end of the high and low-pressure cylinders. For coupling the high and low-pressure rotors a Bibby type coupling is employed, while the low-pressure spindle is coupled to the alternator shaft by means of a semi-flexible coupling. A view of one of the sets in the course of erection in the makers' works is given in Fig. 11, whilst Fig. 12 shows the conditions now existing in the Fulham turbine-room.

For feed-water heating and for deaerator and evaporator steam supply the turbines are bled after the seventeenth stage of the high-pressure cylinder and at the inlet to and after the fourth, eighth, and eleventh stages of the low-pressure cylinder, the deaerator and two-stage effect evaporators being incorporated in the feed system in the manner shown in Fig. 14. All the feed heaters are of the Metropolitan-Vickers Company's U type, and comprise three high-pressure heaters, a gland heater, and a low-pressure heater. Although the high-pressure heaters are on the suction side of the final boiler feed pumps, they are subject to the delivery pressure of the lift pumps, which are designed to maintain a pressure sufficient to eliminate the possibility of cavitation at the inlet to the boiler feed pumps at the maximum condensate or feed temperature of 358 deg. at maximum load. The vessel of the Metropolitan-Vickers deaerator will heat the feed after it leaves the gland heater and will raise it to the saturation temperature of the tapped steam supply. The deaerating chamber is mounted directly above the deaerator storage tank, which has sufficient capacity between its high and low-level limits to cater for any fluctuations likely to occur. To ensure a sufficient quantity of vapour being withdrawn from the evaporator to effect removal of the air liberated in the vessel, the deaerator is fitted with a vent condenser.

Vickers-Armstrongs, Ltd., of Barrow-in-Furness, have manufactured and are now installing the two condensing plants. The contract also covers all the auxiliaries, including duplicate air pumps, duplicate extraction pumps, the complete circulating water system and circulating water pumps, which are of the Vickers-Gill propeller type. The condensers, which are of all-welded steel plate construction, with a single exhaust opening, are claimed to be the largest single shell units constructed in this country. They are of the Vickers regenerative type, and each contains 54,000 square feet of cooling surface. As the size of each shell (Fig. 13) made it impossible to transport them to the site in one piece, each shell had to be split into two carefully designed sections, which would leave a minimum amount of welding to be done at the generating station. The condensers are arranged for "half cleaning." A circulating pump, with separate piping, is provided for each portion of the condenser, the discharge from each being brought away from the watershed independently and united in a common discharge bus main running to the circulating water discharge culvert. On the suction side of each of the two Vickers-Gill circulating water pumps provided for each unit there is a 36in. bore electrically operated sluice valve. Tappings are provided on the circulating water intakes for air and oil cooler water circulation. Both condensers, which have hinged doors at both ends, are guaranteed to maintain 29in. vacuum when operating with circulating water at 55 deg. Fah. inlet temperature. The tubes, which were supplied by James Booth and Co., Ltd., of Birmingham, are composed of Admiralty mixture.

Each condenser has duplicate three-stage steam ejector air pumps, with surface and inter and after

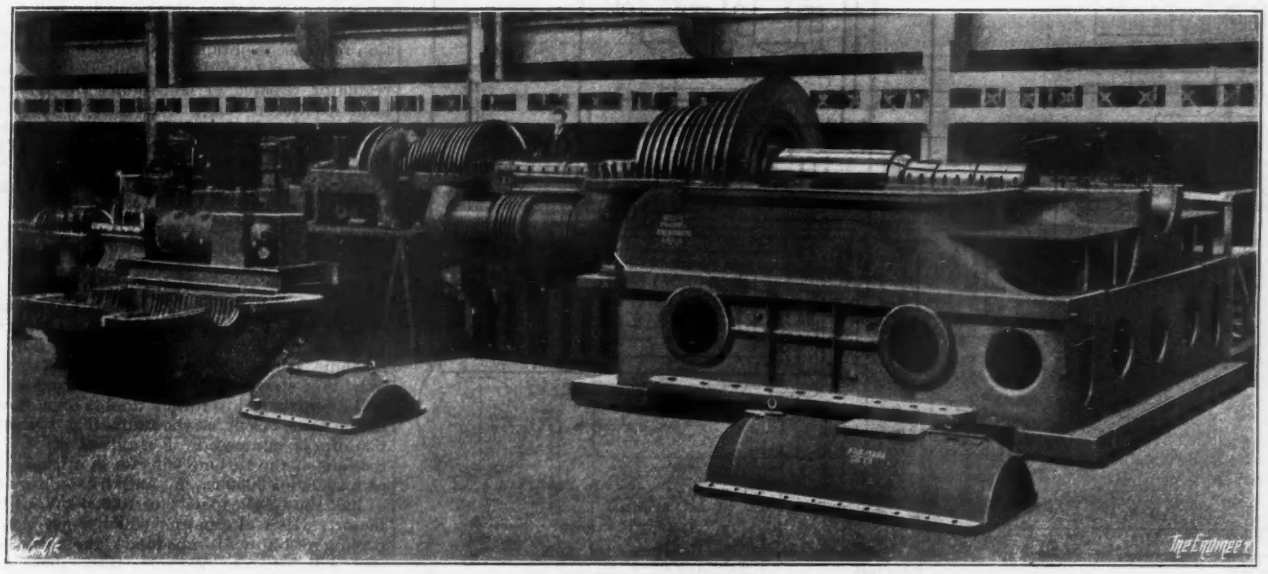

FIG. 11 TURBO-GENERATOR SET IN COURSE OF ERECTION IN MAKER'S WORKS

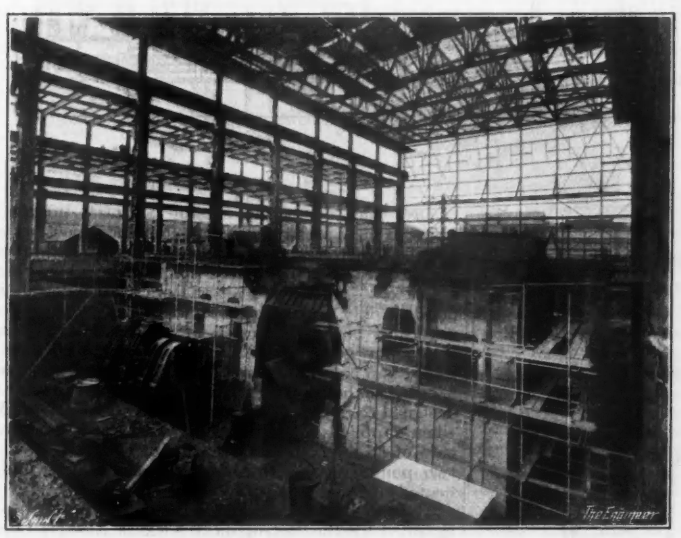

FIG. 12—TURBINE ROOM

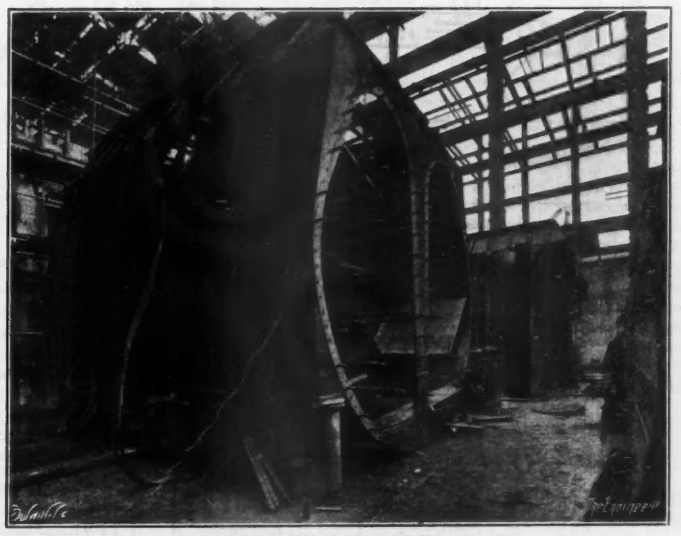

FIG. 13—CONDENSER SHELL

cooling. The primary ejector operates with steam at a pressure of 400 lb. per square inch and 825 deg. Fah., and each pump is capable of handling 100 lb. of dry air per hour. Two single-stage steam-operated air extractors are provided for each plant.

The condensate extraction pumps are being supplied to the order of Vickers-Armstrongs, Ltd., by Drysdale and Co., Ltd., and are to be driven by Metropolitan-Vickers electric motors. Duplicate pumps, each capable of handling 450,000 lb. of condensate per hour against a total head of approximately 180ft., a total head of 23ft. at 485 r.p.m. Each pump is to be driven by a Metropolitan-Vickers slip-ring motor, capable of running at 40 per cent. reduced speed by the use of rotor resistances. The Vickers coil type evaporators are similar to those which the firm has constructed for other power stations in this country and abroad. Two evaporators working in double effect are being supplied for each generating unit, the primary effect taking steam from a low-pressure point on the turbine. Each evaporator contains 1200 square feet of surface. Incidentally, the

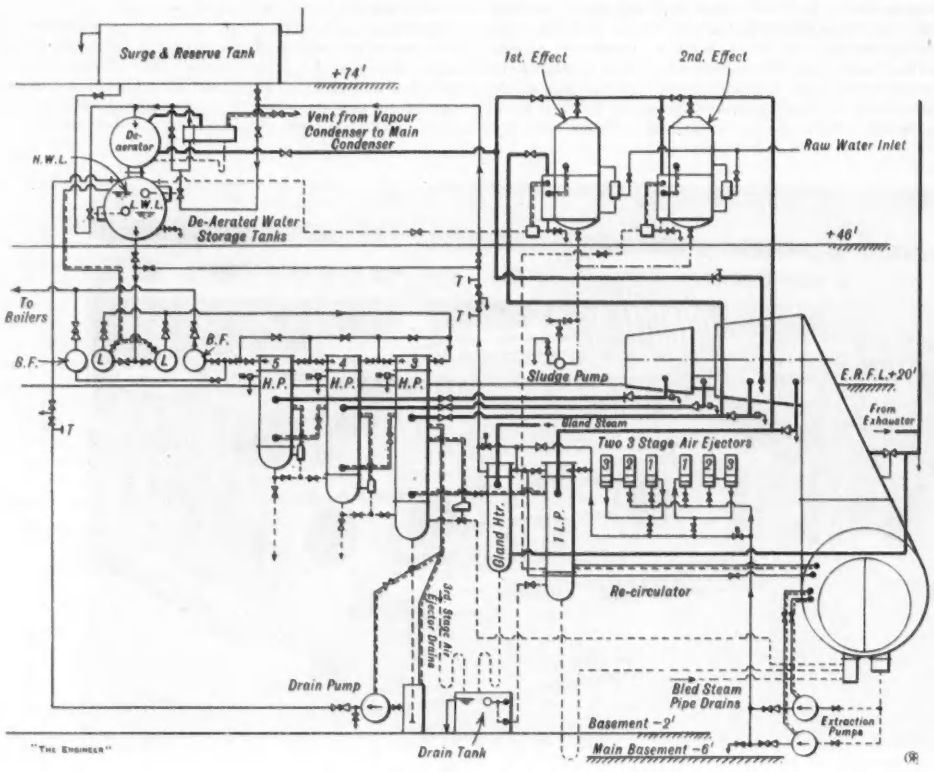

FIG. 14—FEED SYSTEM

when running at 960 r.p.m., are being provided for each plant.

The Vickers-Armstrongs-Gill propeller circulating pumps are two-stage horizontal-spindle pumps, capable in each case of handling approximately 22,000 gallons of circulating water per minute, against a total head of 485 r.p.m. Each pump is to be driven by a Metropolitan-Vickers slip-ring motor, capable of running at 40 per cent. reduced speed by the use of rotor resistances. The Vickers coil type evaporators are similar to those which the firm has constructed for other power stations in this country and abroad. Two evaporators working in double effect are being supplied for each generating unit, the primary effect taking steam from a low-pressure point on the turbine. Each evaporator contains 1200 square feet of surface. Incidentally, the associated firm of Vickers-Armstrongs, the English Steel Corporation, Ltd., supplied the solid forged boiler drums to the order of the Stirling Boiler Company.

The Metropolitan-Vickers alternators are designed for a maximum continuous output of 75,000 kVA at 1500 r.p.m., with temperatures not exceeding those specified in the B.E.S.A. standard rules for machines of this kind. Following the usual practice, the closed cooling system is being employed, the necessary ventilating air being provided partly by centrifugal fans mounted on the ends of the rotor and partly by two motor-driven fans, which will supply air to a common chamber below the alternator. The motor-driven propeller fans have "aerofoil" blades, claimed to give efficiencies up to 80 per cent. Only when the maximum output is required will the separately driven fans be put into operation. At reduced loads they will be shut down when the overall efficiency will be raised by an amount corresponding to the fan motor input. The total quantity of air required by each generator is 100,000 cubic feet per minute, and approximately half of this quantity will be supplied by the separate fans. A very high speed of excitation response is obtained by the use of a pilot exciter of large capacity and a specially designed automatic regulator capable of controlling the comparatively large excitation currents necessary. In general, the mechanical and electrical design of the alternators follows the makers' standard practice. The stator yoke is of the usual fabricated type. The core consists of low loss transformer iron, and all possible precautions were taken to reduce the core loss to a minimum. A special type of rotor wedge has been used for eliminating harmonics in the E.M.F. wave form.

The house service set, which is being manufactured by the Brush Electrical Engineering Company, Ltd., of Loughborough, is a 10,000-kW Brush-Ljungstrom double-rotation radial flow reaction machine, with forty-one radial flow stages and two axial flow stages. The latter have fixed guide blades and are arranged to form a double axial flow exhaust in the same casing as the radial flow stages. All the blading is composed of stainless steel. The two sections of the turbine will run in opposite directions at a speed of 3000 r.p.m., and drive alternators, each of half the total capacity of 10,000 kW, at 0·8 power factor. Both alternators will have a closed circuit cooling system and imbedded temperature detectors, and will generate 50-cycle, three-phase current at 6600 volts. The interior ventilation is entirely axial, which is claimed to ensure a more even temperature through the machine than is obtainable with radial ventilation and to keep the alternator temperature within reasonable limits on sudden overloads. Concentric coils in semi-enclosed slots form the stator windings. Each phase is in a separate tier, an arrangement which simplifies the connections and ensures that coils having the full potential difference between them are at a maximum distance apart. The rotor is a solid steel forging with the slots milled in the periphery. Brush patented spiral groove slip rings are fitted. As the two alternators are connected in parallel, only one of the rotors is fitted with a speed governor, but each section of the machine has an emergency governor which operates at 3300 r.p.m. The steam conditions are 600 lb. per square inch and 825 deg. Fah. The Brush Delas surface condenser is designed to maintain a vacuum of 29in. at 10,000 kW when supplied with circulating water at a temperature of 55 deg. Fah. By means of steam bled from two points on the turbine, the condensate will be heated to 150 deg. Fah.

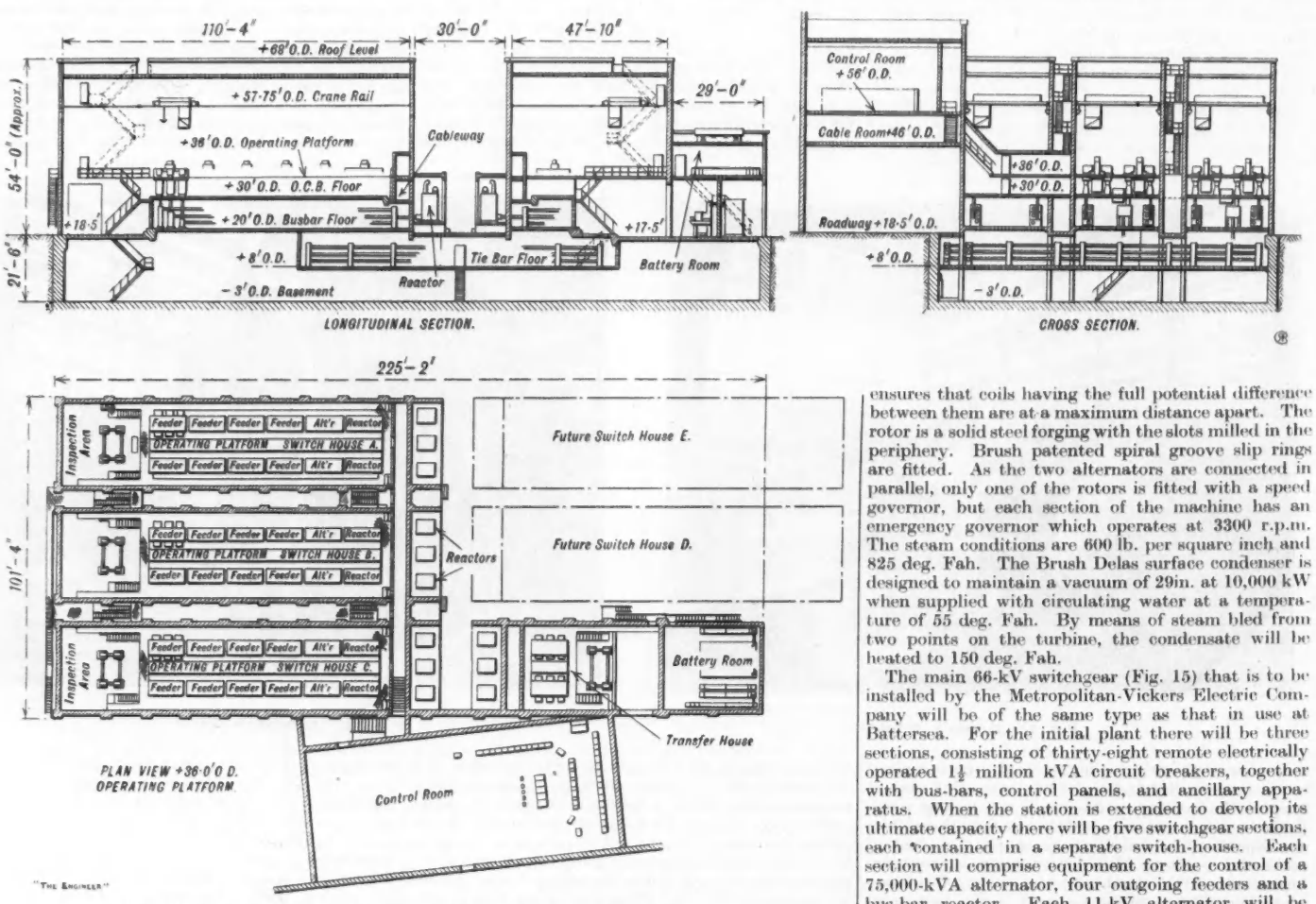

FIG. 15—GENERAL ARRANGEMENT OF MAIN 66-KV SWITCHGEAR

The main 66-kV switchgear (Fig. 15) that is to be installed by the Metropolitan-Vickers Electric Company will be of the same type as that in use at Battersea. For the initial plant there will be three sections, consisting of thirty-eight remote electrically operated 1½ million kVA circuit breakers, together with bus-bars, control panels, and ancillary apparatus. When the station is extended to develop its ultimate capacity there will be five switchgear sections, each contained in a separate switch-house. Each section will comprise equipment for the control of a 75,000-kVA alternator, four outgoing feeders and a bus-bar reactor. Each 11-kV alternator will be separately connected to a step-up transformer, which will raise the voltage to 66 kV, at which pressure all switching will be carried out. It will be perceived from the single line diagram, Fig. 16, that the five main bus-bar sections are to be connected through reactors to a tie bus-bar. Independent transfer bus-bars are being provided for each section, and by means of a transfer interconnector bar and section isolators

it will be possible to couple any transfer bar up to the transfer reactor. The metal-clad vertical lift-up switching equipments permit of the use of oil-immersed isolating plugs, which ensure that all live metal is completely immersed in oil and that no live parts are exposed when the breaker is withdrawn for inspection. There will be complete separation of the phases, and the circuit breakers and bus-bars will be on separate fireproof floors. Metro-Vick cross-jet explosion pot contacts are being fitted to all the circuit breakers, which will be duplicated on each equipment to permit changing over from one bus-bar to the other without interrupting the supply. An overhead travelling crane will be used to raise the circuit breakers from the service to the isolated position, and *vice versâ*, and when in the latter position each breaker will rest on four large guide posts permanently fixed to the breaker supporting frame. The bus-bars and other conductors of this type of switchgear are insulated by means of varnished and treated paper condenser type bushings, and the outer surface of the bushings forming the bus-bars is protected by earthed wire armouring in continuance of the principle of enclosing all conductors in earth metallic shields. The ends of bushings terminate in oil-filled chambers. Between each alternator and its step-up transformer the 11-kV connections will consist of insulated copper conductors. A complete system of interlocks ensures that live metal is inaccessible under ordinary working conditions, and that circuit closings and isolating devices can only be operated in the proper sequence.

Noteworthy features of the design are the adoption of separately fitted chambers for conductors immersed in oil. Apart from sealing purposes at the ends and tie connections, however, the entire insulation of the bus-bars and associated conductors is provided without the use of oil or compound, with the result that there is no common oil supply system and the quantity of oil is reduced to a minimum. To enable oil to be drained, filtered, and changed with little labour and inconvenience, storage tanks will be placed in the basement near the inspection bay of each switch-house. A novel feature of the outdoor oil-immersed self-cooling reactors will be that the connections will enter at the bottom of the tanks. A corridor extending across the ends of the switch-houses will contain all the control cables and access to this corridor will be obtained from each switch-house.

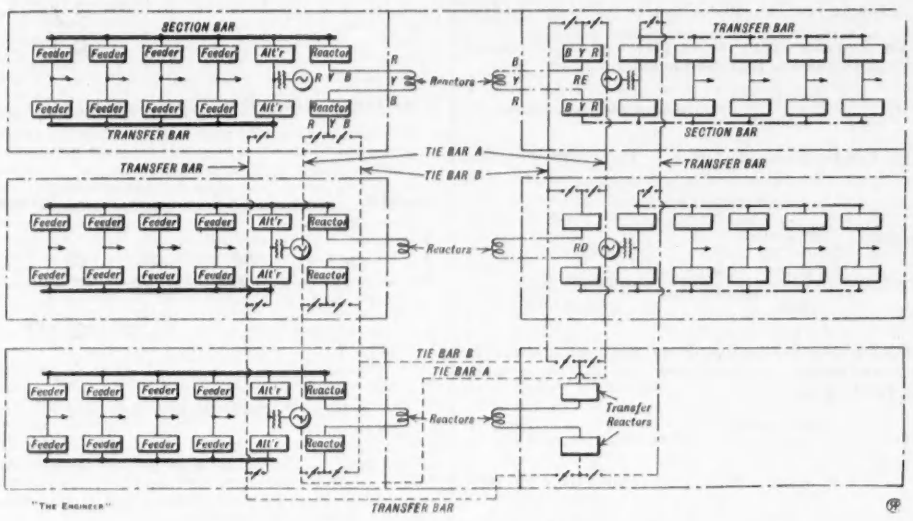

FIG. 16—SWITCHGEAR DIAGRAM

The steel cubicle control board will have rear opening doors. There will be a complete absence of fixing screws and beadings on the front of the panels. The instruments, which will be of the circular and sector types, will be mounted behind the steel panels. Relays will be mounted on a separate board, and separate control desks are being provided for the alternators. Following the latest practice the main control panels will be arranged to form the four walls of the control-room, and walking space will exist between the walls of the building and the backs of the control cubicles.

We are indebted to Mr. H. Clarke, the resident engineer, for permission to inspect the station and for general assistance in the preparation of these articles.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

STEAM OR OIL ENGINE.

SIR,—There is no question that for the production of transmittable mechanical energy in large units the steam engine, or rather turbine, now stands pre-eminent. At the opposite end of the scale there stands the petrol engine. Yet neither of them can be said to hold that position on theoretical grounds alone, for the conditions of test bed trials, on which the theories are based, are seldom reproduced in normal working conditions and practical considerations nullify the designers' attempts to secure high thermal efficiency. In other words, convenience is often as important as calculable efficiency.

There is, however, an intermediate size of prime mover, ranging up to, say, 500 h.p. or so, for which it is still quite debatable which type should be used. In the circumstances I have taken some pains during journeys about the country to ask users why they have adopted either one type or the other, and have generally met the broad assertions that, on the one hand, the steam engine is most amenable and easy to maintain, while, on the other, the oil engine has no stand-by charges and is easy to get under way. But these considerations alone cannot explain the reason for either choice, and it would be interesting to have others' experience.

Take, for instance, a civil engineer with a considerable tunnelling contract. He was full of praise for his oil-driven excavators, but was not satisfied with oil engine locomotives. In the case of the excavators it seemed that it was the general design of the whole machine which most largely contributed to his satisfaction, while the oil locomotives were damned through having no reserve of power to get them out of a hole. In neither case was fuel consumption of any great import.

Another example was a brickyard in the Midlands, which was originally driven by a pair of ancient beam engines. More power was wanted, so they were equipped with high-pressure cylinders and the speed and steam pressure doubled. They worked quite satisfactorily but yet more power was wanted, so an oil engine was installed. It required, however, so much attention that as soon as a supply of "grid" electricity was available it was scrapped and an electric motor put in its place. The beam engines, nevertheless, are still running.

On the river and in our harbours it is noticeable that oil-engined tugs are becoming prominent, but still some of the best-known tug masters continue to order steam machinery for their new vessels in spite of the higher economies claimed by the oil engine makers. In the case of moderate speed cargo boats a preference for oil engines can be understood on account of the lesser overall bulk and weight of the machinery, and their undoubted lower fuel consumption on long voyages, but these considerations do not apply to tugs, except those that go on very long trips. In fact, it not infrequently occurs that oil-engined tugs have to carry water ballast to keep them down in the water and handy in rough weather. Again, the steam engine has very good manœuvring qualities in the way of quick reversal and the gentle picking up of the load. There need be no snatching on the tow rope and the engine can be put from "full ahead" to "full astern" almost as quickly as the bridge telegraph can be operated.

On the questions of length of life and maintenance it is perhaps early to make exact comparisons, but I know steam tugs of forty years or so still running with insignificant repair bills, while the average life of cylinder liners and pistons of oil engines in continuous work is generally put down as six years. One large firm of tug owners tells me that a comparison of six steamers with six oil boats over a period of three years showed that repairs and renewals cost, on the average, £100 and £130 per annum respectively. Again, the cost of lubrication on a steam tug fitted with self-acting solid grease gear is about £5 a year, while the corresponding cost for an oil engine is about £180. The steam engine is open and readily accessible, so that trouble can generally be seen and forestalled, whereas the oil engine is totally enclosed and a bearing may run hot without warning and entail some days in dock. Seeing that a river tug with its crew may be worth about £30 a day to its owners, such delays are very costly.

In the sphere of road transport the petrol and oil engine have, of course, almost entirely usurped the place of steam, but any one who has driven one of the old steamers grieves at their disappearance; that is to say, if he was not concerned with retubing the boiler. With modern advances in the metallurgy of steel, even that trouble should surely be surmountable.

CAPPADOCIA.

December 15th.

UNIVERSITY DEGREES IN ENGINEERING.

SIR,—Many engineers, both with and without university degrees, will concur in the views expressed by some of your correspondents, that workshop organisation and management and industrial economics should be included in the subjects studied for a degree in mechanical engineering. I would, however, point out that only the *principles* of workshop organisation and management can be taught in class. The practice, like all practice, can be acquired only by actual experience in industry. I would also point out that the syllabuses of most engineering degree courses are already so full that it would be impossible to deal adequately with these subjects in a three years' course, unless they were admitted by the University in lieu of some other subject or subjects.

At the Northampton Polytechnic the university degree course for day students occupies four years. Although about ten months of this period are spent in works, the curriculum includes lecture courses on engineering tools, industrial organisation, engineering economics and estimating, in addition to the usual degree subjects. Students spend a considerable time on the machines in the engineering workshops during their first and second years, and the workshops are organised, as regards time recording, storekeeping, working drawings, progress cards, &c., on the most up-to-date industrial models.

Recently a further step has been taken by the introduction of a day course of four year's duration, more definitely related to the demands of modern industry. The essential subjects of the university engineering curriculum are included up to degree standard, but instead of theory of structures, hydraulics and advanced mathematics, there are included physical metallurgy, inspection and testing of materials, industrial administration, economics, costing, estimating, planning and rate fixing, works and sales organisation, tool-room methods, machine tools laboratory and short courses of lectures and practice in welding and foundry work. In the later years jig and tool design replaces engineering drawing. The ordinary machine shop course is taken in the first and second years as in the degree curriculum.

Owing to the limitations of the university syllabus this course does not, at present, lead to a degree in engineering. It is intended for those who desire to enter the field of modern workshop management, and it is hoped that the diploma which will be awarded to those who complete the course satisfactorily will be accepted in lieu of all sections of the associate membership examination of the Institution of Mechanical Engineers.

JAS. E. DOCHERTY,
D.Sc., A.M. Inst. C.E., A.M.I. Mech. E.,
Head of Department.
Civil and Mechanical Engineering Department,
Northampton Polytechnic Institute, London, E.C.1,
December 12th.

[At some of the universities courses in workshop organisation or industrial economics or in subjects of a kindred nature are included in the curriculum for the B.Sc. or equivalent degree. These courses are in general compulsory. As examples we note the following:—At Edinburgh, one of the subjects of the final examination for mechanical engineers is the Organisation of Industry and Commerce. At Birmingham mechanical and electrical engineers are required to take courses in Workshop Practice and Business Principles. At Leeds civil, mechanical, and electrical engineers have to present themselves for examination in Applied Economics. At Sheffield students in all three branches include Industrial Economics in their curricula.—ED. THE E.]

THEORY AND PRACTICE.

SIR,—It seems ironical that when I thought fit to cancel arrangements for the day owing to severe rain, the local water board's inspector arrived on a detailed survey of the whole district for leaky pipes. To my knowledge, this is the first time we have been honoured by such an inspection for twenty years or more.

After the vast expenditure on a water economy campaign, one still feels a more systematic method of utilising our rainfall could be adopted. Besides the often-proposed scheme of interconnecting wet and dry counties that the former might supply the latter, perhaps parochial interests might also be stimulated by a more judicial use of penstocks instead of allowing this gift of Nature to wend its way to the sea or dribble through to the bowels of the earth, where, in many parts of the British Isles, it causes great inconvenience to the workings of mines.

Every large suggested engineering scheme is now damned by book-ridden economists, and a saying of one, viz., "the infinity in the study of economics is knowing all about nothing," will always be remembered by me. Also, in this era, when men's minds are blinded by milliards of forms, and intelligencies stunted by a thousand

and one correct procedures, and it is necessary to have a degree before being allowed to punch an adding machine, and the talk at all engineering meetings is about getting down again to fundamentals, we would do well to spend more time working in harmony with Nature and the Heavenly Bodies, and thus making use of real finance. The morale of the people has sunk many points during the period of depression, and yet the dishing out of insurance benefit, and the sending of men to training centres, continue to flourish. It is useless to train men for jobs that are not available. The only practical tuition to be given by these centres should be that of jobbing. By that I mean teaching the man to run a little business on his own, and perhaps, in promising cases, loaning a little capital. We have now the proposed help for depressed areas, but I have yet to hear or read of any scheme other than that of bolstering up decadent industries and thus continuing another vicious circle.

With the completion of the electrical grid in sight, soon, another body of educated and highly skilled engineers will be thrown on the market, and as railway electrification around large industrial centres is still mainly a dream, they will gradually be absorbed in jobs where their lights and enterprise will be wasted.

Leyton, December 14th. W. PENSTONE.

HIGH RUPTURING CAPACITY FUSES.

SIR,—Referring to the article on "High Rupturing Capacity Fuses," in your issue of November 2nd, a comparison is made between a 3000-ampère breaker set to trip at 1500 ampères and a 500-ampère fuse, possibly melting at 950 ampères.

The comparison is unfair, because the breaker cannot begin to think of doing anything under 1500 ampères, while the fuse starts to heat at the first application of current.

Calling 1500 and 950 ampères the "setting" in both cases, the peak ratios are 21·4 and 21·0 respectively; consequently, a fuse melting at 1500 ampères would pass 32,000 ampères.

The slow rise of current with the breaker and the high excess voltage indicate considerable reactance in circuit.

This may be due to the impedance of the overload and blow-out coils, but in an ordinary circuit these are small relatively to the total impedance, and on such a circuit a fuse would show a similar voltage rise.

The statement is made that the core has a breakdown value of 10,000 volts per inch! Cold, possibly; molten, absolutely No!

Also, "practically the whole of the arc energy (20,000 ampères at 400 volts for 0·019 sec.) is absorbed in the thermo-chemical reaction" of $\frac{5}{16}$ in. of stuff!

This explanation is, to say the least, completely unconvincing.

For GEORGE ELLISON, Ltd.,
J. ANDERSON, Chief Engineer.

Birmingham, 20, December 1st.

SIR,—In reply to Mr. Anderson's letter of the 1st inst., comparative tests were taken by an important electricity supply undertaking, whose engineers wished to compare the operation on short circuit of an air circuit breaker set to trip at 1500 ampères, and an English Electric high rupturing capacity fuse having a continuous rating of 500 ampères.

After the air circuit breaker had cleared the short circuit it was found that the main contacts, as well as the arcing contacts were badly pitted, and it was necessary for these contacts to be cleaned up before the circuit breaker could be used again.

The fuse, however, cleared the short circuit silently (there was a loud report when the circuit breaker cleared), and without damage to the fuse cartridge or contacts.

The article criticised by Mr. Anderson stated that the comparative figures were obtained for "the breaker and fuse operating under identically the same conditions." As Mr. Anderson challenges this statement, the diagram of connections of each test is given in Fig. 3. It will be seen that the inductance of the circuit neglecting the apparatus tested was the same for each test. Mr. Anderson refers to reactance and impedance, which is incorrect.

Mr. Anderson refers to "the slow rise of current with the breaker." This is also incorrect, as is shown in Fig. 1, which reproduces to the same scale the oscillograms of the fuse and circuit breaker short-circuit tests. It will be seen that the rate of rise of current was greater in the case of the circuit breaker test than in the case of the fuse test, and is accounted for by the lower resistance of the circuit breaker.

Mr. Anderson states that the high excess voltage in the case of the circuit breaker may be due to the blow-out coil. The following figures show that the inductance of the blow-out coil equals 45·5 per cent. only of the circuit inductance, and thus it is clear that the major cause of the high-voltage peak on the circuit breaker oscillogram is the steep fall of current which gives a high value of $\frac{di}{dt}$. Taking first the circuit breaker record, an analysis of the final stage of the arcing period where the greatest voltage peak occurs provides the following data:—

(1) $\frac{di}{dt} = \frac{1{\cdot}0 \times 10{,}000}{0{\cdot}55 \times 3} = 6060$ ampères per milli-sec.

(2) E.M.F. of self-induction, $E\,i = 1210 - 400 = 810$ volts.

$$E\,i = \frac{di}{dt} \times L$$

Therefore

(3) $L = \frac{E\,i}{\frac{di}{dt} \times 1000} = \frac{810}{6060 \times 1000} = 0{\cdot}000134$ henry (0·134 milli-henry).

Taking next the portion of the fuse record where the greatest voltage rise takes place, a similar set of figures can be obtained.

(1) $\frac{di}{dt} = \frac{0{\cdot}675 \times 5000}{0{\cdot}8 \times 3} = 1410$ ampères per milli-sec.

(2) E.M.F. of self-induction, $E\,i = 530 - 400 = 130$ volts.

$$E\,i = \frac{di}{dt} \times L$$

Therefore

(3) $L = \frac{E\,i}{\frac{di}{dt} \times 1000} = \frac{130}{1410 \times 1000} = 0{\cdot}000092$ henry (0·092 milli-henry).

Since the fuse has no measurable inductance, the latter figure may be assumed as the inductance of the test circuit. Therefore, 0·134—0·092 milli-henry = 0·042 milli-henry, representing the inductance of the blow-out coil of the circuit breaker.

The comparison between the fuse and circuit breaker is in any case quite equitable, since the blow-out coil is an inherent part of the breaker and would always be fitted in practice.

Fig. 2 reproduces the oscillogram of a test which was one of the same series, the connections being exactly as in Fig. 3, except that the fuse tested was a 100-ampère rewireable type porcelain handle fuse. It will be seen that a voltage surge having a peak value of approximately 1400 volts is recorded, this being due to the steep rate of decrease of the current.

It is interesting to note that in this test the 100-ampère rewireable fuse failed to clear, and that the circuit was finally opened by the air circuit breaker connected in series.

Mr. Anderson refers to a 500-ampère fuse "possibly melting at 950 ampères." Reference to Fig. 1 shows that the fuse element volatilised at 20,000 ampères; therefore the statement "possibly melting at 950 ampères" has no meaning so far as the short-circuit tests are concerned. Had the circuit breaker being tested been rated at 500 ampères, and set to operate at 1000 ampères, it is very unlikely that the pre-arcing time would have been reduced to that of the fuse, *i.e.*, 0·01 second. Pre-arcing time of the circuit breaker may be divided into three periods:—(*a*) Time for overload relay to operate; (*b*) time to pick up lost motion and inertia in the trip mechanism; (*c*) time required to overcome inertia of main moving contacts.

The first item is for a given design of circuit breaker substantially independent of the circuit breaker rating, and represents a time handicap which has to be made up by the circuit breaker before the trip gear commences to operate. This time period represents an appreciable percentage of the whole pre-arcing time. In respect of items (*b*) and (*c*), these periods were reduced as far as possible in the actual test by selecting a new circuit breaker of first-class design.

The breakdown voltage of the core, *i.e.*, in the neighbourhood of 10,000 volts per inch, is, as Mr. Anderson suggests, a value cold. The article did not state that this was the breakdown voltage of the core when molten, and a reference to the current curve of the fuse test oscillogram clearly shows how the increasing value of the core resistance gradually reduces the current to zero.

Mr. Anderson queries the statement that "practically the whole of the arc energy is absorbed in the thermo-chemical reaction." Perhaps he can indicate any other possible way in which the arc energy can be dissipated, bearing in mind that our 500-ampère fuse has twenty-one elements in parallel, and that the fuse cartridge remains hermetically sealed after the short circuit is cleared.

A. M. POOLEY,
Manager, Fusegear Section, the English Electric Company, Ltd.

Stafford, December 11th.

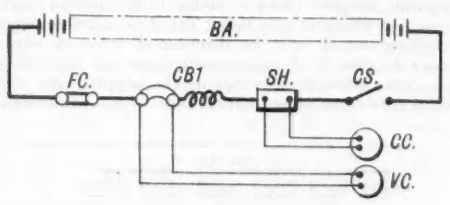

DIAGRAM OF CONNECTIONS - CIRCUIT BREAKER TEST

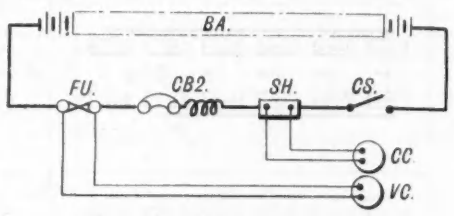

DIAGRAM OF CONNECTIONS - FUSE TEST

"THE ENGINEER"

B A—4,000 Ampère Hour 400 Volts Battery—Maximum Short Circuit Current = 35,000 Amps.
C B 1—3,000 Amp. Air Circuit Breaker with O/L Coil Set at 1,500 A. No Time Lag.
C B 2—Ditto, but O/L Coil at Max. Setting.
F C—Fuse Contacts Bridged with Copper Bar.
F U—500 A. H.R.C. Cartridge Fuse.
S H—Oscillograph Shunt.
C C— ,, Current Coil.
V C— ,, Voltage Coil.
C S—Closing Switch.

FIG. 3 TEST CONNECTIONS

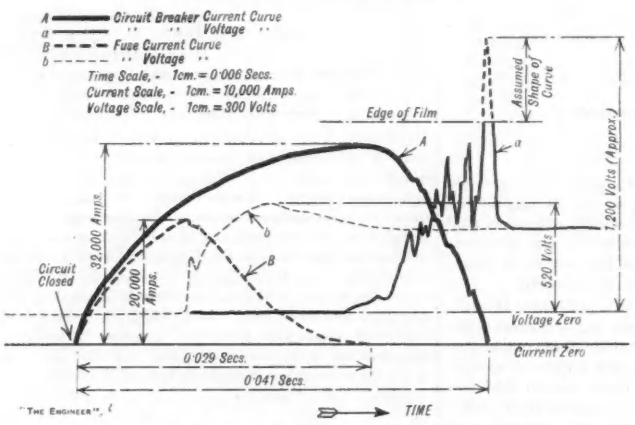

FIG. 1—CIRCUIT BREAKER AND CARTRIDGE FUSE TESTS

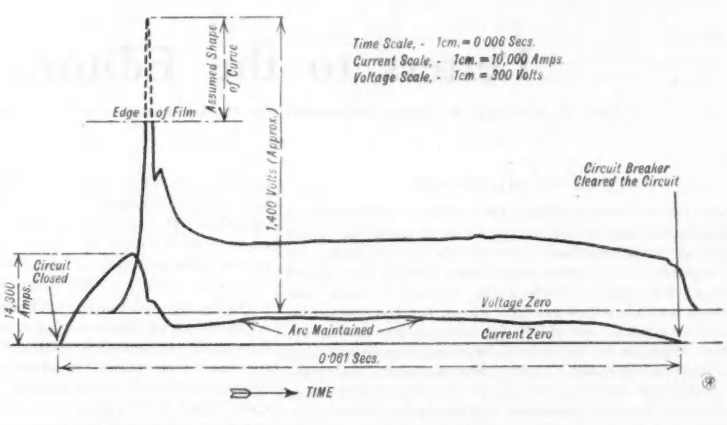

FIG. 2—CIRCUIT BREAKER AND RE-WIRABLE FUSE TEST

ACCORDING to the report of the Irish Free State Electricity Supply Board for the year ending March last, extensions of the transmission and distribution systems during the year included the provision of 67½ miles of low-tension overhead mains, 12½ miles of low-tension underground mains, 2½ miles of 5-kV and 5½ miles of 10-kV cables and 50 miles of 10-kV transmission lines, while 31½ miles of low-tension overhead mains and 2½ miles of 38-kV transmission lines were reconstructed or strengthened. The transformer capacity of the existing 38-kV transformer stations was increased by 3000 kVA, and two new stations with a capacity of 640 kVA were erected. The total number of 10-kV and 5-kV transformer stations was increased to 605, having a capacity of 95,458 kVA.

Railway and Road Matters.

WHEN the Stanmore branch of the then Metropolitan Railway was opened in December, 1932, provision was made for a station at Queensbury, between Kingsbury and Cannon Park. This new station has now been provided and was opened on Sunday, December 17th.

THE Minister of Transport, answering a question addressed to him on December 10th, said that he could not say how many occupation crossings there are, but there could be little doubt that the number of such crossings largely exceeds the number of public road crossings, and there may be 10,000 or more.

THE Railway Assessment Authority fixed the amount for rating purposes of the Southern Railway as £2,180,000, which was £328,000 over the present net annual value. The company has therefore appealed, under the Railway Assessment Act, to the Railway and Canal Commissioners. Certain public authorities want, on the other hand, the figure to be £3,000,000. The appeal is now being heard by the Railway Commission.

HEREIN, on November 30th, allusion was made to the approaching lapse of the powers of canal companies to raise their carrying charges over pre-war level. That fact appears to have inspired each of the four grouped companies to have a clause in their respective Bills for the present session for "permanent provision with regard to the tolls and charges leviable by the company in respect of their various canals and navigations."

As long ago as 1864 parliamentary powers were given to build a railway between Watford and Edgware, which was to join, at the latter place, the Great Northern Company's Edgware branch. The line was not, however, constructed and the powers lapsed. A Watford and Edgware Railway Company was subsequently incorporated and a public company has now been formed, the three directors of which are all officers of the London Passenger Transport Board.

To succeed Mr. C. H. Bressey, whose appointment as Engineer for the Survey of Highway Development in Greater London has already been announced, Mr. Hore-Belisha, Minister of Transport, has appointed Mr. F. C. Cook, M. Inst. C.E., at present Deputy Chief Engineer, to be Chief Engineer of the Roads Department of the Ministry, and has further appointed Mr. A. J. Lyddon, M. Inst. C.E., at present Divisional Road Engineer for the Northern Division, to succeed Mr. Cook as Deputy Chief Engineer.

THE resumption and conclusion of the Wormley crossing coroner's inquest on Monday, December 10th, was followed, two days later, by the further inquiry, on behalf of the Ministry of Transport, by Colonel Trench. Those proceedings could not, however, be completed as the guard of the train was not yet well enough to give evidence. The driver of the motor vehicle was there and related how he looked up and down the line and drove over the down line. He had got on to the up road when he saw the train. Not being a railwayman, he did not understand what the signals meant. Before the inquiry was further adjourned representations were made as to the great anxiety of those using the line as to their safety. Colonel Trench, in reply, said that the question of occupation crossings was a most difficult one and one which was causing considerable anxiety to the Ministry. To this a representative of the L.N.E.R. added that the railway company was extremely perturbed and the matter was being considered by the chairman, directors, and officers.

ACCORDING to the Railway Returns for 1933, in the May of which year "summer tickets" were introduced, the number of passenger journeys, when compared with 1932, increased 2·77 per cent. Receipts from passengers increased by 0·42 per cent. and the difference in the ratio of increase was, the Returns observe, attributable in part to those cheaper tickets. A return is given of the percentage of full fares and reduced fares in 1924—ten years ago—and 1933. In the former year 64·97 per cent. of the passenger journeys, other than those of workmen and season ticket holders, were at full fare but in 1933 the proportion made at full fare was only 16·59 per cent. The receipts from passenger fares were 65·59 per cent. from the full-fare passenger in 1924, but in 1933 the full-fare passengers only contributed 21·88 per cent. The average receipt per passenger journey fell from 5s. 4·76d. for first class in 1932 to 5s. 3·66d. in 1933 and from 1s. 3·64d. for third class in 1932 to 1s. 3·28d. in 1933. The average receipt per passenger journey for all classes dropped from 1s. 4·77d. to 1s. 4·32d. Workmen brought in a little more in 1933 than in 1932; the average receipt per journey was 3·53d. in 1932 and 3·57d. in 1933.

IT will be forty years on the 22nd instant since an accident occurred which, as to its cause, had had no parallel since the Act of 1871 came into force and has had none since. It happened on December 22nd, 1894—a Saturday in a year, like the present, when Christmas Day fell on Tuesday and, therefore, a day of considerable traffic—at Chelford, between Manchester and Crewe, on the London and North-Western Railway. The time was late afternoon, and in the growing darkness it was not noticed that the high winds that had been prevailing had blown a wagon on to the down line. A down goods train passed soon afterwards and struck the derelict wagon and threw it foul of the up line. Immediately afterwards an express from Manchester to Birmingham approached on the up line and collided with the wagon, which it drove before it. The engine and some carriages of the express were derailed and there was considerable telescoping because the path of the derailed engine and coaches was confined between the wall of the up platform and the down goods train. Fourteen passengers were killed. The Board of Trade report on the accident recommended that during high winds wagons should remain attached to their engine, or, if close shunted, should have the wagon brake at once applied. That suggestion was consequent upon the wagon in question, when shunted off a previous train, not being left inside the safety points of the siding. As a result a rule was made that "guards, shunters and others concerned must exercise great care in the securing of vehicles in sidings to prevent them from moving and fouling other lines or being blown out or otherwise escaping on to a running line."

Notes and Memoranda.

A NEW series of non-sparking mining tools is being marketed in America, says *Chemical Industries*. They are stated to be made of wrought beryllium-copper, are non-magnetic and non-sparking, and by actual test are almost as durable as steel tools of similar design and size.

THIN strips of crepe rubber have been placed under the tramway rails in Durban, says the *Electrical Review*. The borough engineer anticipates that the rubber will not only reduce the noise made by passing tramcars, but will also prolong the life of the track by reducing wear and tear.

A NEW type of aircraft is being constructed by Short Brothers to enable heavily loaded long-distance aeroplanes to leave the ground with a full fuel load. It consists of joining together two separate aircraft, the upper having a high wing loading and the lower a less high wing loading. The two machines take off under the combined power of the engines of both, and when the desired height has been reached, the upper machine is released from the lower.

AT the Annual Convention in Pittsburgh of the International Acetylene Association, Mr. T. R. Moxley described the use of a sprayed aluminium coating as a scale preventive for annealing boxes. This coating, which ranges from 0·010in. in thickness on the sides of the boxes and 0·020in. thickness on the top, is covered with a layer of potassium silicate which protects the aluminium from furnace temperature and provides opportunity for the aluminium to alloy with the iron.

A PROCESS for producing cheaply, from waste and scrap amber, a new liquid substance called "Parabernol," claimed to be suitable for many purposes for which natural shellac is utilised, has been discovered in Germany, says the *Chemical Trades Journal*. According to the new process, waste and scrap amber is first ground into powder. After being washed and purified, this substance is converted into a syrupy mass by the introduction of certain chemicals, then dried and again reduced to powder; after which the dried mass is processed and without difficulty converted into a thin liquid.

A TIMBER bridge built in 1761 at York Village, Maine, has recently been replaced by another timber bridge of almost exactly similar design. It has thirteen spans of 17ft. each and one of 30ft., while the width is 22ft. In the course of the studies made for this bridge it developed that a similar type could be used to economic advantage as well as appropriateness in many rural districts, where a concrete bridge would be a discordant note in an otherwise harmonious landscape. The estimated cost of the concrete bridge was 26,500 dollars and of the wooden bridge 16,000 dollars, a saving of 35 per cent., or 10,500 dollars. The interest on this saving is enough to pay for the maintenance and to leave a surplus sufficient to build a new bridge in fifty years. In that length of time bridge needs are, says the *Engineering News-Record*, likely to change in many communities.

AT a meeting of thirty-two representatives of local authorities and other organisations co-operating with the Department of Scientific and Industrial Research in the investigation of atmospheric pollution, Dr. G. M. B. Dobson stated that the new method which had been developed at the Building Research Station for estimating sulphur in the atmosphere was now being used at twenty-seven power stations. It was hoped that it would be adopted still more widely by local authorities, as it gave, with little expense, information of great value concerning one of the most destructive of atmospheric impurities. He also referred to trials which were being made of a photo-electric method for recording daylight. If successful, this method would provide a virtually automatic means for measuring the amount of the sun's ultra-violet light cut off by smoke haze.

MANY methods of cleaning turbine blades have been tried out at Cahokia Station, and it was found, says an abstract in *Mechanical Engineering*, that fly ash from the combustion of pulverised coal has the proper characteristics of fineness, cheapness, and abrasiveness for this purpose when used with compressed air through a gunite machine. Fly ash is exceedingly fine and handles readily in the blower. The particles, while reasonably hard, are not as sharp as sand, being well rounded in the burning process. Unlimited quantities of it are available at practically no cost. Fly ash was tried in a gunite blower using compressed air to clean the turbine rotor of a 50,000-kW turbine. The results were very satisfactory. Only two men were required to do the entire job, and it took about one-half the time normally required for scraping. To check whether the ash was wearing away the metal a spare blade was weighed on a laboratory balance before and after cleaning. Calculations show that less than 0·0005in. of metal was worn away.

As a result of the recent disastrous fires on two French liners, the French Government, through the Ministry of Mercantile Marine, has now issued specifications with which all paints and varnishes to be used in the internal decoration of passenger vessels must comply. The specifications are published in full in the *Journal Officiel*, from which the following particulars are given in the *Chemical Trades Journal*. It is stipulated that the ignition temperature of the permitted products shall not be lower than 300 deg. Cent., and that on combustion or on decomposition under the influence of heat, there shall be no liberation of copious fumes or noxious gases. A second class of paints which shall be entitled to the affix "de Sécurité," are such as have an ignition point not lower than 400 deg. Cent. A further interesting clause in the specification is the stipulation that the paints are not to have a flame propagation index greater than certain specified limits. The test for this purpose is carried out in a horizontal tube in which the product under test is uniformly distributed, and through which an air current is passed at constant speed. The tube is heated at the point of air entry, and periodic attempts made with a small pilot flame to ignite the product. As soon as ignition takes place the flames are withdrawn. The tubes are fitted with reference marks whereby the speed at which the flame travels can be ascertained.

Miscellanea.

AFTER only ten years' service the 22,000-ton cargo liner "Minnetonka" has been beached at Bo'ness for breaking up. She was capable of carrying 27,000 tons of cargo and 100 passengers.

IN an official report of the Amalgamated Engineering Union, it is stated that the number of unemployed members on January 1st this year was 29,309, representing 16·03 per cent. The latest figure is 19,111, representing 9·76 per cent., a drop of 10,198 for this year. For the past month the decrease has been 332.

A DEPOSIT of salt, wind-borne from the sea, at the Portobello grid sub-station, Edinburgh, affected three transmission lines. The deposit caused flashovers and some of the insulators collapsed. Lines to Hamilton, Galashiels and Glasgow were impaired, the output being automatically cut off in each case, so that no danger arose.

THE Blaenavon blast-furnaces have been purchased by Thos. W. Ward, Ltd., of Sheffield, for demolition. These ironworks have been in existence for 150 years. There are three blast-furnaces, with ten Cowper stoves, turbo-blowers, Halberg gas cleaning plant, &c. The colliery and steel activities of the company are to be continued.

ACCORDING to official returns, coal output in Russia totalled 76,000,000 tons in January to October, or 14,500,000 tons more than in the corresponding period of last year. The planned output for the year was 76,000,000 tons. Production costs in the industry increased 3·6 per cent. last year, but declined 3·3 per cent. in the first eight months of this year.

THE first plant in Russia for the concentration of mercury ore has been started up at Nitikowka. The ore, which has a mercury content of 0·2 to 0·3 per cent. will be worked up into a concentrate containing 15 to 20 per cent. of the metal. The initial plant will have an annual capacity for dealing with 300,000 tons of ore. Mercury itself will be produced at a further factory, plans for the erection of which are well in hand.

AN extract in the *Iron and Coal Trades Review* describes Lopinite, a new type of coal found in China. This Loping coal contains 3·72–26·21 per cent. of ash, and has a heating value of 5886–8130 g.-cal. On an ash-free basis it contains water 0·23–1·26, volatile matter 45·50–65·15, fixed C 34·36–53·50 per cent. The sulphur, 2–5·8 per cent., is chiefly organic. Low-temperature carbonisation of this coal yields semi-coke 54·28, oils 33·05, liquid plus ammonia 3·12, gas 8·11 per cent.

AN OIL-ELECTRIC tug for Thames owners has been launched from the Woolston shipyard for Thames barge-handling. The new tug, which is 77·5ft. long by 19·5ft. broad, has a double-armature propelling motor of 400 b.h.p. at 100 r.p.m., taking current from two 4-cycle, single-acting airless injection engines, each coupled to a generator of 165 kW output at 530 r.p.m. Bridge control is being fitted and the ship will be in every respect in line with the most modern towing practice.

THE Turkish Government is understood by the *Shipping World* to be considering the question of abolishing port dues on ships bunkering at Turkish ports. Of the total production of coal in 1933 of 1·32 million metric tons in the Ereglis-Zenguldak district, 480,000 tons were exported, 340,000 tons shipped as bunker coal, and 500,000 tons consumed in the country. The Turkish Government hopes that in the next two years the country will be able to dispense with coal imports and to compete with British and Polish coal in the Mediterranean.

A NEW electrically operated cable railway has recently been completed and put in operation in Switzerland between Schwyz and the tourist resort of Stoos, which lies at a height of about 4250ft. above sea level. The line has a length of 1489 yards, including a bridge and two tunnels. The carriages are designed to accommodate fifty passengers and travel at a speed of just over 4½ m.p.h. The cable is 35½ mm. in diameter, and has a safety factor of 9. It is operated by a 125 h.p. asynchronous three-phase, six-pole motor, and is provided with automatic stopping gear at the terminal stations.

A *Times* report from The Hague says that the Minister of Ways and Waterworks has replied to various questions put by members of Parliament with regard to the failure of the oil-electric trains introduced last spring. Most of these trains, after running for about two months, have been taken out of service, owing, it is stated, to trouble with the motors owing to vibration. The majority of the motors had, said the Minister, been seriously damaged after having run about 15,000 to 20,000 miles, and they were being repaired. Various alterations had been made, but it was still uncertain whether the services could be resumed.

THE Canadian Department of National Defence, in co-operation with the Department of the Interior, has issued a new map of Canada showing the airports, intermediate aerodromes, and seaplane ports and anchorages. It is issued as an aid to aviators and all interested in flying activities. The various types of landing stations are designated by separate symbols. There are shown forty-eight public airports, twelve private airports, thirty-one intermediate aerodromes, eighteen public seaplane ports, nine private seaplane ports, twenty seaplane anchorages, and three Royal Canadian Air Force landplane stations and five seaplane stations.

A NEW development in sea and air travel has been brought about by linking up the Cunard White Star Atlantic service with the Imperial Airways service across Europe and throughout the Empire. Arrangements have been completed for the Cunard White Star to act as general agents for the Imperial Airways throughout the United States and on board their Transatlantic liners. Travellers from the United States to Europe wishing to complete their journey by air after disembarking at Cherbourg or Southampton, will be able to reserve aeroplane accommodation at the same time as they purchase their ocean tickets. Thus it will be possible for passengers journeying to inland points in Europe to save a great deal of time after landing.

THE CHALAIS-MEUDON AEROPLANE TESTING STATION

(*For description see page 610.*)

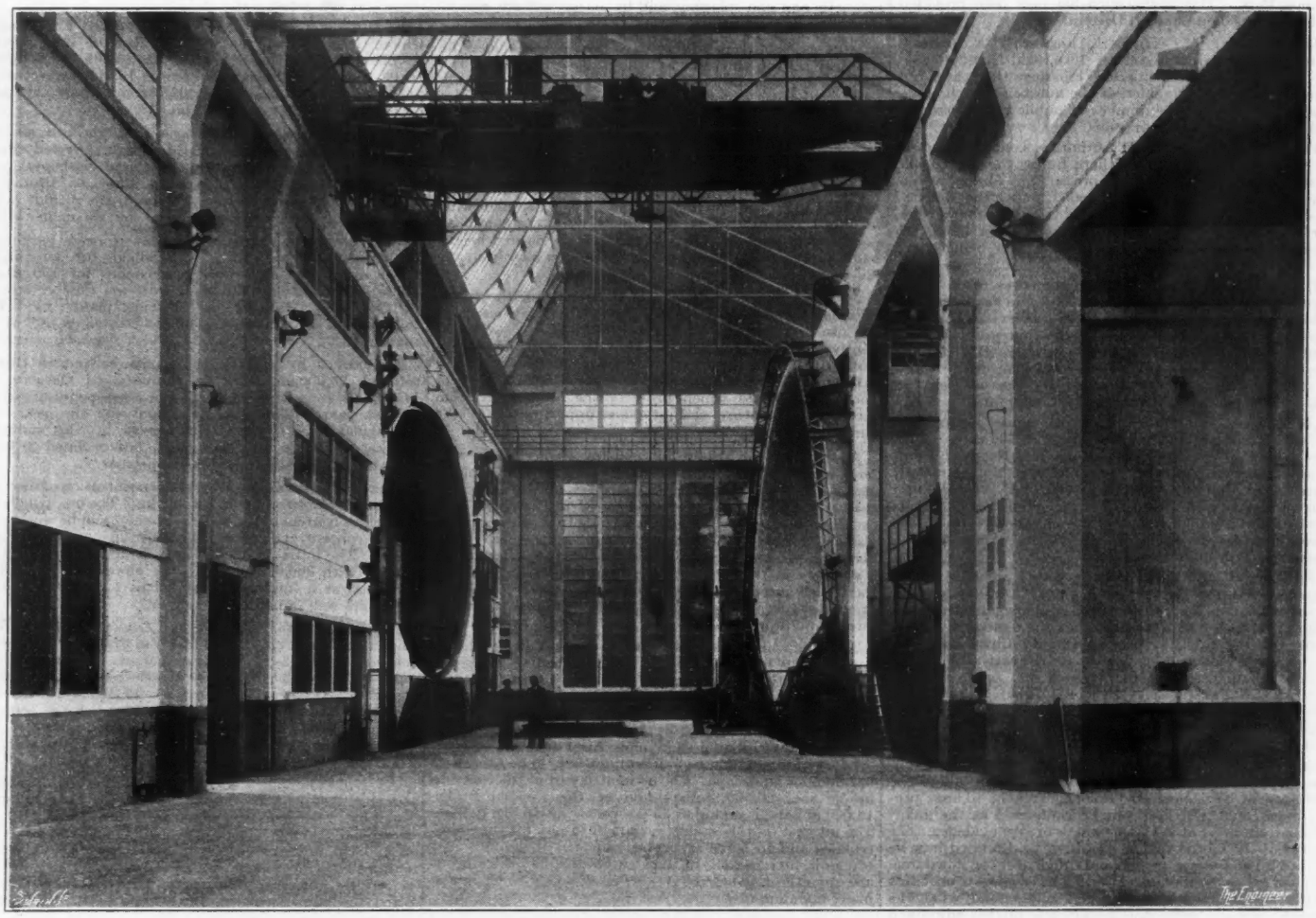

FIG. 6—THE TEST ROOM SHOWING INLET PASSAGE ON LEFT AND DIFFUSER ENTRY ON RIGHT

FIG. 7—THE SUCTION CHAMBER AND FAN DIFFUSERS

The Engineer

DECEMBER 21, 1934.

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DEATH.

On Tuesday, the 18th inst., in his 74th year, W. CROSIER HAYNE, a governing director of Moreland, Hayne and Co., Ltd.

THE MACHINE TOOL AND WORKSHOP ECONOMY.

WE conclude to-day the series of four articles in which Mr. Holloway, an experienced works manager, has discussed the recent Machine Tool Exhibition at Olympia. Not for a moment do we suppose that all who have read these critical articles will agree with everything the author has said. Yet it will be clear to all that Mr. Holloway has kept his eye throughout on a desirable target. Some may hold that his aim has not been true or that his shafts have been directed towards a goal that does not, in fact, stand for all that he supposes. The object he has, manifestly, had before him during the preparation of his review is "economical production." There is no other *raison d'etre* for the machine tool. If it will not help us to produce more economically than we could without it, then we might with advantage return to the old hand processes, with a few elementary machines, of our forefathers. There is at this day at least one industry in which the pole lathe, of unknown antiquity, is still used; not because excellent machines for doing precisely the same work do not exist, but because in the particular circumstances and nature of the trade it suffices. In higher branches of engineering than the crude turning of chair legs the same thing obtains. The best machine for a job is not necessarily the most complete, the most accurate, the most costly. A far simpler tool may in the long run be more economical. It has been Mr. Holloway's endeavour to examine critically recent advances in machine tool design and to balance their perfections and refinements against the total cost of their products.

We do not hesitate to say that such a searching inquiry was necessary, but our author could do no more than indicate the lines upon which potential purchasers should conduct their examination of the relative qualities and characteristics of machine tools. He could not enter into the details of specific cases. That must be left to the potential purchaser. No one who is not intimate with all the details of a business can ever say what is the best course for it to pursue. Even the experienced works manager finds it no easy task to pick from a number of alternatives the one which will give the greatest return. Fortunately for him, several of our leading machine tool making firms maintain advisory departments upon which, with just a trace of reserve, reliance may be placed. With their large experience they are in a position to specify the type of machine that will be best for any postulated work, or to indicate the grouping and respective numbers of machines that will give the most economical output. But before any such advice can be given accurate premises must be formulated. Mr. Holloway has, very rightly, stressed a fundamental necessity in the equipment of machine shops. It is uneconomical to have the productive power of the tools out of balance. The manager who, attracted by the superlative merits of a new machine, attempts to intercalate it with other machines which are incapable of keeping pace with it suffers not only by the cost, probably on a high scale, of the new tool, but may actually lose money on the hours that it is standing idle because it has outrun its companions. We say "may," because, obviously, conditions do occur when it pays to do work at a high speed even if the tool cannot be employed up to its full capacity. But, generally speaking, the most economical course is so to match machines that all are employed all the time. In large specialised factories that is not difficult. But in smaller works, and particularly those engaged in general engineering, the ideal cannot be approached. It is then that the general-purpose machine has its chance, and the works manager finds himself faced with the very difficult problem of deciding on what degree of perfection he is justified in spending money. As far as the tool room is concerned, the answer is, we suggest, easy. The best machine that the purchaser can afford is always the best for that position. But in the workshop the problem can only be solved by a careful weighing of the cost of the machine, its operation, and maintenance, against the value of the products it is likely to be required to turn out. Sometimes one may hear it said that a general-purpose machine is always profitable because it need never stand idle. We should be glad to have our experienced readers' opinions on that point. Looking at the equipment of some general-purpose machines, capstan lathes for example, it is difficult not to feel that it has been brought to such a degree of elaboration that changing it must be a lengthy and costly operation. There again the question of economics intrudes and may be complicated by the admixture of a human factor in the form of reluctance to take down a carefully adjusted equipment and replace it by another.

Of the many other points of which Mr. Holloway has written it is unnecessary to say more here than that they are all essentially practical; the sort of points the works manager must be ready to face. That some of them will not have the sympathy of the machine tool maker is highly probable. He, taking delight in the work or seeking to reach a higher degree of perfection than that attained by his competitors, has added in some cases refinements or conveniences, about the value of which our author expresses some doubt. He questions, for example, the redundancy of electric motors and an over-extended range of feeds and speeds. He is not convinced that it pays to put in a motor to perform an operation which may only be required at fairly long intervals and could be done, for less expense, by mechanical means. On the other hand, he wonders why it is that so few makers have given attention to the means of handling work into and out of machines. The contrast is certainly curious. On the one side we have special provision for performing a given operation at long intervals, and on the other no attempt to facilitate an operation which may be fairly frequent and which may involve costly delay. We save, so to speak, on the roundabouts and throw the money away on the swings. That is not sound engineering. The machine tool designer may say that it is not his business to supply handling appliances; that that is a matter of shop organisation and equipment. But we suggest for his consideration that in many cases more time and money could be saved by the provision of such appliances than is economised by some of the rarely used mechanism which he now includes as an inducement to the purchaser. It is with such practical issues as that that Mr. Holloway's articles have dealt, and for that reason they are, we believe, worthy of careful reading, both by machine tool makers and users.

Copper Trade Troubles.

FOR some years copper has been amongst the most depressed of the world's metal industries; but at length a gleam of hope is seen in the agreement which, it is expected, will be ratified by the producers early in January. It is an ironical reflection that the market, which, a few years ago set itself out to fight a great combination of producers, should now see its salvation in another international arrangement. Yet there are trade experts who believe that the period of depression through which the copper industry has passed is the direct outcome of the misguided policy of the producers in 1926. In that year they created a combine which they declared controlled 98 per cent. of the world's copper resources. The price was then 14¼c. per lb., or £66 per ton. The combine was formed to check the decline in the price of copper and to revolutionise the distributing methods of the trade by organising a system of direct supply from producer to consumer. For a time prices gradually advanced until in March, 1929, the world price was 25c. per lb. c.i.f., or, in sterling, £112 per ton. By the end of April, 1929, it had dropped to 18½c., or £84 12s. 6d., and the combine then bent its energies upon maintaining the quotation at that figure. The methods of the organisation, however, provoked hostility on the part of consumers and dealers in all the export markets, and they met the somewhat haughty attitude of the producers by a policy of buying as little as possible, and that only for near delivery. Then came the usual consequences of an inflated market price. Those responsible for the combine had forgotten that large quantities of copper scrap were available in many parts of the world and refineries were set up in consuming countries which produced copper from this material. This exercised a devastating effect upon the market. Prices steadily fell and stocks accumulated, and although the combine held together until the middle of 1932, in the latter period of its existence it had ceased to have any real control over the market or production. Finally it broke up, with copper available at 4·50c., or £28 10s., and left the American producers with stocks of nearly a million tons to finance. This accumulation has weighed upon the market ever since and, in spite of repeated reductions of output, by the American mines; there never has been hope of a recovery.

Until recent months no serious efforts had been made to deal with the world situation, and so depressed had the copper trade become that the market was as anxious as the copper producers themselves to see a return to a healthy and economic price. There has, of course, been an enormous change in fundamental conditions during the past few years, and perhaps the greatest factor has been the expansion of production by low-cost African mines. In 1928–1929 the United States produced 856,000 tons of copper out of a total of 1,820,000 tons, South America coming next with 358,000 tons, and Africa next with 151,000 tons. Last year, out of a total of 902,000 tons, the American production had dropped to 210,000 tons, that of South America to 120,000 tons, whilst the African output had risen to 165,000 tons. The development of these African properties has greatly influenced the development of the situation. These companies can speak on equal terms with the Americans, and now that fresh negotiations for a world regulation of copper output are in progress, the result will depend largely upon their attitude. It is true that as a result of the curtailment of production in America and the efforts which have been made to dispose of their copper, the Americans have reduced their stocks to about 450,000 tons. The National Industrial Recovery Act also contributed towards changing the situation by enabling American producers to fix the domestic price for their copper at 9 c., whilst the world c.i.f. price has fluctuated between 6 c. and 7 c. Naturally, this has introduced another factor into the negotiations which have been proceeding between the American producers and those of other countries. The former would like to force an advance in the world price to a figure approximating that ruling in their home market, whilst the newer and distinctly aggressive African producers have been disinclined to cut outputs to an extent necessary to accomplish this. It is possible that an arrangement would not have been reached had it not been that the shareholders of the various companies began to exert pressure upon their directors. Whether this was wise or not is open to argument, since it is obvious that the directors of the companies are more familiar with the conditions which

should be provided for than are the shareholders. Nevertheless, the agitation certainly had its effect, and the most recalcitrant negotiators have now, it is said, come to terms. It is understood that the plan proposes either to retain production at the level of the year 1934, in the expectation that stocks will be liquidated and that prices will gradually rise, or to make a cut of 20 per cent. upon that rate of output in order to obtain a more rapid appreciation.

Unbiassed observers may see in the eagerness with which the market desires an international agreement the swing of the pendulum from the hostility with which the combination which was wrecked two and a half years ago was regarded. The producers of copper are only human, and if the opportunity is given them to raise prices without any check there will be a strong temptation to recoup themselves for the losses they have suffered. There is a danger therefore that history may repeat itself. The price of 9 c. for copper should be sufficiently profitable to satisfy the majority of mining companies, but there are, certainly, some which will wish to continue production, and to whom it will not afford a large margin of profit. It is therefore possible that if the more severe of the two schemes is adopted the 9 c. figure will not be regarded as sufficiently remunerative, and that there will be a claim, with which the market is familiar, that 12 c. would be a fair quotation. But at that figure mines which can produce profitably at 8 c. would certainly be reluctant to continue a policy of curtailment, and once again the copper position might dissolve into competitive chaos. This is a consuming country, and since the Empire producers will be included in the new arrangement, if it is ratified, consumers here will follow its consequences with close interest and possibly some apprehension. It is understood that the Canadian mines which produce copper will have their output taken over at an agreed price by other interests, which will make the necessary marketing arrangements. The mines in the British African possessions which are amongst the cheapest producers in the world are in a different position, and they will, of course, be included in any arrangement which is come to. To some extent the market is protected by the situation created by the producers themselves, who have in many cases filled the consumers' works with copper and have allowed them to use it as and when it was required at the current daily price. Considerable quantities are thus in existence as invisible stocks. This may protect the market from any violent rush of buying, and allow the price to rise gradually to a reasonable level.

Air Swirl in Oil Engines.

THE INSTITUTION OF MECHANICAL ENGINEERS.

AS an aid to the distribution of fuel in heavy-oil engines, swirl, or the rotation of the air charge, is becoming increasingly popular. So far, however, little is on record concerning the principles governing the production and use of swirl. To remedy this defect Mr. J. F. Alcock on Friday evening of last week, December 14th, presented before the Institution of Mechanical Engineers a paper reviewing the subject generally and giving in particular an account of the results obtained from an experimental investigation of one of the three possible forms of swirl, namely, induction swirl as distinct from compression or combustion swirl. The paper attracted a good audience among whom were to be counted most of those who an hour earlier had met to constitute the Internal Combustion Engine Group, the first of the specialised sections to be formed within the Institution under the Council's new arrangement. A total of eighty-four members joined the Group on its formal establishment. Mr. Alcock's paper provided the new Group with an attractive subject for debate, but, as will be gathered from the following account, the discussion was dominated for the most part by a side issue, namely, whether Mr. Alcock was correct in suggesting that the air swirl in the engine experimented with was in the form of a free vortex. An abstract of the paper will be found elsewhere in this issue.

Mr. D. R. Pye, of the Air Ministry, said that the paper was a timely one. The heavy-oil engined omnibus was, almost without notice, now invading the streets of London. Its success was attributable very largely to the adoption of the swirl principle. From the first, the Air Ministry had encouraged Mr. Ricardo in his investigations into improved means of bringing the air to the fuel as contrasted with sending the fuel to find the air. No heavy-oil aero-engine was at present in service use in this country but that fact was to be explained not by any lack of progress in its development but by the developments which had been made in the petrol aero-engine as a direct outcome of Mr. Ricardo's work on the heavy-oil engine. The heavy-oil engine had in fact given the petrol engine a great push and enabled it to retain the first position. In that connection it was interesting to note that the Bristol Company's heavy oil engine shown at the last R.A.F. display was actually lighter than the same company's petrol engine of five years ago. The paper, he proceeded, left him with a feeling that it was a gallant effort to give scientific coherence to a number of problems which really had not very much in common. There was not enough solid fact behind the author's distinction between high, medium, and low swirl engines. No one, for example, had ever measured the rate of swirl in a Junkers engine. It was probably quite high although the author referred to it as a medium swirl engine. Again all the author's measurements of the so-called swirl ratio, N/n, were made in one type of cylinder only. That ratio had no real physical meaning behind it. We did not know how the intrusion of the measuring vane affected the swirl. If without the vane the motion of the air was, as the author suggested, a free vortex, then it was certain that the insertion of the vane in the combustion chamber would upset the motion and would introduce some doubt as to what was being measured. What happened to the jet in Mr. Ricardo's engine was a very interesting question in view of the fact that with a clean exhaust the engine could burn as much as 80 to 85 per cent. of the total air charge. He was not quite happy regarding the author's suggestion that the air motion was in the form of a free vortex. The establishment of a free vortex required some kind of "sink" as in the case of water running out of a bath. He could conceive how the requisite conditions might arise during the descent of Mr. Ricardo's piston but it puzzled him to understand how they could exist during the compression stroke.

Professor C. H. Lander was interested in the paper as a contribution to the improvement of combustion in oil engines and also from a more general point of view, namely as an illustration of the difference between the burning of liquid or gaseous fuel and solid fuel. When liquid or gaseous fuel was being burned it was of first importance to get the hydro-carbon or other fuel molecules into intimate contact with oxygen molecules. The conditions to be fulfilled were however entirely different in the case of the combustion of solid fuel. A lump of coal occupying 2 cubic feet would require for its complete combustion all the air in the lecture theatre. The only way to effect the combustion was to pass the air as a stream over the surface of the coal and to carry away the products. The ratios of air to fuel were the same in both cases. That consideration led him to the belief that the only way in which to obtain short-flame combustion with powdered fuel was to give the air a streamline motion and to throw the fuel across it. Like Mr. Pye he was not satisfied that a true free vortex existed in the Ricardo combustion chamber. He could not picture a free vortex existing during the compression stroke. If a cinema film of a free vortex were run backwards it would represent the imposed conditions but he did not think that a phenomenon such as that film would depict could occur in Nature. The lower speed which Mr. Alcock had detected on the outside of the swirling volume of air might have been caused by the friction of the air against the combustion chamber wall and was not of itself sufficient evidence for the existence of a free vortex.

Mr. T. F. Hurley, of the Fuel Research Station, said that he had been in charge of a long series of experiments on the effect of turbulence in petrol engines and the influence on it of different methods of ignition with different fuels. As means of measuring the distribution of velocity in the air inside the cylinder head the Ricardo swirl meter and the Sass stationary vane device suffered from the disadvantage that they obstructed the air flow and compelled it to travel with a uniform velocity. At the Fuel Research Station a Pitot tube device had been developed for the purpose of exploring the velocity distribution. Such a tube introduced a minimum of obstruction, and, when the engine was "motored," enabled the velocity to be measured at a point in the flow. The pressure difference indicated by the Pitot tube was measured on a U-tube manometer after pulsations had been damped out. The indication given by the tube when it was placed close to the wall of the cylinder head agreed very well with the known inlet velocity of the air and in other respects the arrangement had been proved to be satisfactorily accurate. Observations made with the tube showed that as it was moved radially inwards the velocity of the air gradually decreased as in a forced vortex, but as the centre was approached the velocity began to rise as in the case of a free vortex. The resultant curve of the distribution of velocity was a compound of the straight line law of a forced vortex and of the rectangular hyperbola law of a free vortex. It was found that as the volumetric efficiency of the engine decreased the tendency to the establishment of the conditions of a free vortex became greater. He suggested as a solution of the paradox that a forced vortex might predominate during one portion of the engine cycle and a free vortex during another.

Mr. Robert Cook, also of the Fuel Research Station, gave further details of the experiments referred to by Mr. Hurley. The engine used, he said, was very similar to the Ricardo sleeve valve engine. A plate glass window had been fixed in the upper part of the cylinder head and through it sparks of burning material drawn in with the air could be observed and photographed. By means of this arrangement it became clear that the natural motion of air in any cylinder was a swirl. The air entering the cylinder at a speed of about 2 miles a minute was bound to strike some portion of the curved surface of the wall and thereafter it followed the cylindrical boundary. The difference between indiscriminate turbulence and rotational turbulence or swirl was one largely of speed. Efforts were made to produce purely indiscriminate turbulence but signs of swirl were always noticed. In a further experiment the glass plate in the cylinder head was smeared with oil containing particles of carbon in order to make visible the path followed by the air in contact with the plate. The oil was seen to move towards a nucleus at the centre of the cylinder, the path taken being an equiangular spiral. There seemed to be two main lines which the development of combustion chamber design could follow, namely a high degree of swirl with a single jet and a moderate degree of swirl with multiple jets. The first-named proceeding seemed to have a tendency to result in rough running. That fact was not perhaps particularly important in the case of heavy road transport vehicles but for private cars the second-named procedure seemed to offer the greater advantages.

Wing-Commander Cave-Brown-Cave expressed his regret at what had been said about the free vortex for he had always believed that the motion of the air in a Ricardo "Vortex" combustion chamber was just about as pure a free vortex as one could obtain. He still believed that the conditions in a Ricardo engine of the type experimented with were ideal for the production of free vortex motion. The measuring vane of the Ricardo swirl meter affected the nature of the motion and reduced it practically to a forced vortex. The Sass meter had the disadvantage that its inertia affected the readings. The Pitot tube method of measuring the distribution of velocity in the swirling air must result in offering much resistance to the air flow and in addition in view of the damping arrangements introduced between the tube and the manometer must result in the figure read on the manometer being a highly complex quantity. He therefore suggested as an alternative measuring means the use of wires carrying electric currents and the cooling effect exercised on them by air blowing across them. That method of measuring the distribution of velocity was very responsive and was non-obstructive.

Mr. R. E. Strube said that for a multiple jet central injection engine he had found that the optimum swirl ratio was between 6 and 8 as compared with the value of 10 found for the Ricardo engine with a "Vortex" combustion chamber. He was surprised that in the Ricardo experiments a large vane had been used for measuring the speed of the swirl. A short vane near the centre of the chamber was to be preferred. He had found that the speed of rotation of a short vane gave a reading in accordance with what would be expected from calculations and not widely different therefrom as in the author's case. He thought that the introduction of excess turbulence would alter the optimum swirl ratio of 10 reported by the author.

Mr. A. E. L. Chorlton regretted that the author had not touched upon the historical aspects of his subject and in particular, that he had not mentioned the work of Akroyd Stuart who originated the use of turbulence in internal combustion engines. Arising out of his work engines with directional compression turbulence had been developed in Lincolnshire some years before the war and in those engines the exhaust was perfectly clear. The tangent type of combustion chamber, introduced by Mr. Livens, was the forerunner of all modern forms.

Professor G. V. Lomonossoff contended that the whole theory of the heavy-oil engine could be reduced to three fundamental limiting equations expressing the fact that there were limiting values to the mean indicated pressure, the product of the cylinder diameter by the crank shaft speed and the product of the crank shaft speed by the piston stroke. The author of the paper had found that the maximum possible mean indicated pressure under clear exhaust conditions was 110 lb. without swirl and 145 lb. with a high swirl. Those figures, the speaker said, were correct only for solid injection engines. With air injection he had reached in 1925 a figure of 150 lb. *without* swirl. There were, he continued, two common means of increasing the limiting mean indicated pressure, namely the adoption of swirl and the adoption of supercharging. The author had correctly remarked that the employment of swirl made the engine much less sensitive to changes in the injection conditions.

Supercharging, on the contrary, increased, in his experience, the sensitiveness of the engine in that respect. Those facts, he thought, were of decisive significance as regarded land transport. For railway work they implied, in his view, that the future belonged to swirl and not to supercharging. For railway and road transport work the compression type of swirl was, he held, to be preferred as it was less sensitive and more easily maintained than either the induction or the combustion type of swirl. The paper, unfortunately, gave no experimental data for the compression swirl engine and he was doubtful whether the data derived from an induction swirl engine could be extrapolated to it as the author had suggested. The author had shown that in an induction swirl engine the use of swirl increased the limiting mean indicated pressure. He had, however, omitted to remark that swirl also increased the limiting value of the product of the cylinder diameter by the crank shaft speed. With the same size of cylinders, therefore, swirl permitted the adoption of higher engine speeds. That conclusion, he thought, was most important from the point of view of the oil-engined locomotive. Concluding, he remarked that the author's representation in Figs. 9, 10, and 11 of the nature of the effect exercised on the jet of fuel by the air swirl was rather hypothetical. He suggested that photographic means might be developed whereby the actual state of the turbulence could be observed. Any kind of vane or anemometer, as the author himself admitted, was too rough an appliance for the purpose. It would naturally be very difficult to photograph the paths of air and oil particles in the combustion chamber of an oil engine but it would not, he thought, prove more difficult than the accomplished photography of the paths of atoms.

Mr. C. B. Dicksee discussed the merits of single and multiple hole nozzles and expressed a preference for the single hole type. Mr. W. A. Tookey dealt briefly with the form of combustion chambers and remarked that some designers had found it advantageous in the "Comet" type to modify the throat in such a way as to interfere with the production of swirl.

The President, Mr. Charles Day, said that, from his own experience with engines of the non-swirl and swirl types, he could confirm the broad accuracy of the statements made in the paper. Discussing the vexed question of the size of the measuring vane he remarked that such vanes, it was clearly recognised, gave only a guiding indication of the effects produced by a change in the design. If, for instance, after some modifications of the inlet conditions had been made the vane revolved at a higher speed than before all that was deduced was that the modifications had increased and not decreased the rate of swirl.

The author was left with little time to reply to the discussion. He had omitted historical references, he said, partly in order to economise space and partly in order to avoid treading on dangerous ground. He himself felt, like Mr. Pye, that his paper represented the gathering of a number of scattered facts into one orbit but he hoped that it would induce others to fill in the gaps. His use of the term "free vortex" was intended to be by way of analogy rather than an exact description of the movement of the air in the combustion chamber. It should be borne in mind that accelerated motion was frequently very different from steady motion and that as a consequence the path followed by the air in its swirl was no doubt very complex. He criticised the use of a Pitot tube for measuring the velocity distribution on the ground that small changes in the manometer tubes and their connections led to very large differences in the results registered. He did not intend to imply that the "squish" action illustrated in Fig. 9 was wholly responsible for the inward flow of the air. That it could not be so was proved by the fact that in an engine with a "Comet" type of combustion chamber, in which there was no "squish" action, the inward flow must have been very effective in order to give the engine its observed capacity to burn even more than the 80–85 per cent. of the total air charge recorded for the Ricardo engine with a "Vortex" combustion chamber.

Literature.

Scientific Papers and Addresses of the Hon. Sir Charles Parsons, with a Memoir by Lord Rayleigh. Edited by Hon. G. L. PARSONS. Cambridge University Press. 1934. Price 15s. net.

THERE is no engineer in any part of the world who does not hold in respect the name of Sir Charles Parsons. This collection of the principal papers, lectures, and addresses which he delivered will therefore be welcomed both as a personal souvenir of a great inventor and as a record of his work.

From the former aspect the brilliant memoir by Lord Rayleigh will be enjoyed by all. Many short biographies of Sir Charles have been written, but not one of them has the intimate personal touch which Lord Rayleigh has been able to impart to his contribution to this volume. He gives us a living portrait of Sir Charles and illuminates it with anecdotes which are familiar to the inventor's intimate friends, but until now have not been placed before the public. All those who worked with Sir Charles knew, sooner or later, both sides of his character—his occasional hastiness and his good nature, which in the end always triumphed. His forgetfulness and indifference to time and dress when engaged in absorbing work are other traits with which his friends came into contact.

The greater part of the volume is devoted to the papers on the steam turbine which were delivered under Sir Charles' name alone. He wrote many others in conjunction with members of his staff, but these are, with one or two exceptions, not included in this collection. We observe, also, that many of the papers have been abbreviated. This was a wise and necessary course, for since many societies were anxious to have papers from Sir Charles on the same subjects, repetition was inevitable. Enough has been retained by the Editor to cover the whole history of the invention and development of the steam turbine ashore and on the sea. In this part there will also be found his B.A. addresses, particularly the famous one to Section G at Cambridge in 1904, in which he discussed the possibility of driving a bore-hole twelve miles deep into the earth.

In the second part will be found three papers in which an account is given of Sir Charles' efforts to produce artificial diamonds. We believe that in his later years Sir Charles came to the conclusion that he had in fact never succeeded in producing real diamonds, but the account of the methods he employed in his experiments are not the less interesting.

To this collection of papers the Editor has added two appendices which deal with subjects to which Sir Charles devoted a great deal of study, time, and money, but about which he never, as far as is known, delivered formal papers. The first, written by the late Mr. A. Q. Carnegie, who for many years personally interested himself in the invention, deals with that very ingenious pneumatically operated loud speaker—the Auxetophone. The element of this instrument, which was first demonstrated just thirty years ago, is a valve controlling the flow of air to a horn and operated by the vibrations of some selected part of a musical instrument. In 1906 Sir Henry Wood used it in his Queen's Hall orchestra, and Van Biene—of "Broken Melody" fame—fitted it, certainly on one occasion, on his 'cello.

The second appendix is an outline of the work which Sir Charles undertook on optical glass. In that somewhat alien field he showed the same ingenuity, courage, and scientific imagination which characterised his work on the steam turbine.

If it cannot be said of Sir Charles Parsons' papers that they are comparable with the research papers of the great physicists, yet it was very desirable that the inventors' own accounts of the most far-reaching revolution in power production since the days of Watt should be presented in a collected and convenient form.

Sound and Noise.

A LECTURE on "Sound and Noise" was given at the Royal Institution on Wednesday night, December 12th, under the auspices of the Institution and the British Science Guild, by Dr. G. W. C. Kaye, Superintendent of the Physics Department of the National Physical Laboratory. Mr. Hore-Belisha, the Minister of Transport, was in the chair.

The lecturer remarked that the study of sound, which not many years ago was mainly of academic interest, had laid the foundations of present-day acoustical industries of world-wide importance. Side by side had come the growth of noise to which many inhabitants, particularly of large cities, were being subjected, though in only a few countries was the problem of its mitigation being tackled scientifically. It was unfortunate that Nature had embedded the ear in a mass of sound-conducting bone, so that hearing was the only one of the five senses which could not be effectively defended.

Most of us would be tempted to define noise as sound made by someone else, but the definition likely to be adopted internationally was that based on the subjective conception that a hearer of a particular sound called it a noise if he himself did not desire it, regardless of whether his neighbour did or did not similarly find it a nuisance. We could not, of course, divest noise of its psychological aspects.

Man had developed very many and ingenious ways of making sounds and noises. In some every-day events the noise was only a small by-product, for example, only about one thousandth part of the energy of a dropped weight or of a hand-clap appeared in the form of noise. This figure was increased to a few per cent. in the case of motor horns and loud speakers, and even up to 30 per cent. or more for the loud speakers used for talking pictures. By comparison with many sounds, the human voice was very weak, and even during shouting the output was only about 0·001 watt. Suitably equipped, an orchestra of seventy-five had a normal acoustic output of about 0·5 watt, which in strident passages might be increased 100 fold—quite enough, if it could be so applied, to light an average electric lamp. In the event of the drivers of all the motor vehicles in Greater London taking it into their heads to sound their horns together, the total acoustical output of the simultaneous blast would probably be of the order of 200 h.p., that is, more than enough to drive a London omnibus at full speed.

For the purposes of the measurement of the loudness of noise, a reference standard of sound had been chosen. This standard, which consisted of a pure note of a frequency of 1000 cycles per second, played much the same part as a standard candle did in the photometry of electric lamps. The adjustable intensity of the standard note was measured on a scale of decibels above an arbitrary zero near the threshold of hearing; the corresponding loudness was then expressed on a numerically identical scale of phons. The various subjective noise meters on the market determined the equivalent loudness of noises in phons by matching them by ear against the standard note. The objective meters, on the other hand, depended on the physical measurement of the intensity by a microphone. They could, however, be made to simulate the ear, and so compare the loudnesses of similar noises.

The National Physical Laboratory had measured and examined noises on the road, on the rail, on the sea, and in the air. Most people shared the view that acoustically sports cars and motor cycles as a class compared very unfavourably with the average family car, which excited little complaint, except when the engine was warmed up at nights in quiet streets, whether by racing or screeching along in a low gear. Motor horns were getting more powerful, and public opinion clearly regarded such horns with disfavour, particularly if they were high pitched. There was much to be said for horns with low notes. The Minister of Transport's beneficient suppression of horn hooting at night had taught many peope to drive more quietly in the daytime also.

The new acoustics laboratory at the National Physical Laboratory had greatly facilitated investigatory work on the steps required to reduce sources of noise, on the noise-proofing of walls, and on the noise absorption of building and other materials. Many present-day building structures were effective conductors of sound and vibration. Some impact sounds only lost 1 decibel of intensity in about 1000 yards of steel. In the case of single homogeneous walls, one could forecast the insulation against sounds arriving by air, since it was wholly a matter of weight. One could only get higher insulation without excessive weight by using composite or isolated double partitions. The spacing apart was important in the case of light double partitions or windows; incorrect spacing might result in more harm than good.

The last line of defence against noise in a building was the use of surface absorbents. Ordinary hard plaster was a better reflector of sound that a mirror was of light, so that in modern rooms which were designedly free from curtains, upholstery, and carpets, the noise level might become uncomfortably high unless one of the commercially available acoustic absorbents was applied to the walls or ceilings. These absorbents, which could be got to simulate almost any finish, were also valuable for correcting bad acoustics of concert halls, &c.

To judge by the experience of the National Physical Laboratory, there was marked evidence of growing industrial activity and public interest in this country on the whole question of noise abatement.

SIXTY YEARS AGO.

THE mines profusely dotted along the north coast of Cornwall sadden the visitor of to-day with their reminder of past prosperity. Here and there one may still be found at work. A few, such as the Wheal Kitty, are being carefully tended against the awaited time when it will be profitable to pump them dry and restart operations. But for the most part the tall engine houses, bereft of their pumps and boilers, stand, roofless and without windows, on the hill tops and the adits and shafts are decayed beyond restoration. In the little valleys which run down to the rugged shore a few miners remain, washing, for a bare living, the sand and the mud from the ditches in which, through the centuries of working, tin ore particles have accumulated. The others have gone, some to new occupations, some to the gold mines of South Africa, and slowly but certainly Nature is reclothing the scarred hillsides and the unsightly dump heaps in a green dress. To the engineer the scene is particularly sad for he cannot but be aware that the Cornish mines and their mechanical needs inspired the early development of his profession in these islands. Newcomen, Trevithick, Hornblower, Woolf, Bull, Murdock, James Watt and many others of the pioneers laboured in the Duchy's interest and in doing so laid the foundations of engineering throughout the world. We may have forgotten much of what they did and what it led to but, if in nothing else, the association of the county with the history of our calling survives familiarly in the names "Cornish engine" and "Cornish boiler." Although engineering is still practised within its boundaries, the great days are gone, never, it seems certain, to return.

We do right to revere Cornwall as having cradled our art, but if we turn the pages of the less distant past it will be found that, in middle age, she proved a careless mother. It is with a shock that we read in our issue of December 18th, 1874 a leading article entitled "Boiler Explosions in Cornwall." To boiler engineering as then practised in the county we could find no other term to apply than "simply disgraceful." The commonest precautions for the protection of life were, we said, systematically ignored. The loss of life from boiler explosions at the Cornish mines was reported by Dr. Le Neve Foster, the inspector for the county, to be much greater than that from a similar cause at all the collieries in the United Kingdom put together. Within a year there had been nine explosions of boilers at the tin mines. The boilers, we said, were frequently of bad design and construction and were worked in defiance of all the laws of safety. The foulest water was fed to them and the mud was allowed to accumulate until it had to be dug out with a spade. In one instance within our knowledge an explosion had destroyed the boiler-house. A new boiler was installed, but the house was allowed to remain in ruins and the *debris* of the old boiler to lie where it had fallen. In another instance a boiler which had exploded was found by Dr. Foster to have had a four-foot flue 34ft. long without a single strengthening ring along its length. Even when new it ought not to have been worked at a pressure beyond 16 lb. or 20 lb. After fifteen years' service when the plates had become thin it was being pressed to carry 32 lb. when it blew up and scattered the stones of the boiler-house to a distance of 70 or 80 yards. Of the nine explosions recorded by Dr. Foster, eight were described by him as having been caused by wear and tear or malconstruction or both. Ubiquitous as the insurance companies' inspectors seemed to be in other parts of the country, in Cornwall, we commented, they had no footing.

A Geared Turbine Unit for Cargo Boats.

AN extremely interesting attempt to meet the competition of the internal combustion engine for the propulsion of cargo boats is being made by the Parsons Marine Steam Turbine Company, Ltd.

The company has produced, and demonstrated on Friday last in the works at Wallsend, a complete self-contained unit suitable for an installation of about 2000 s.h.p., and rotating the propeller shaft at 70 to 80 r.p.m. The unit, as will be seen from the photograph reproduced as Fig. 1, is complete with reducing gear and condenser, and is designed for about 200 lb. steam pressure, so that it may be used with ordinary Scotch boilers. The circulating, condensate, lubrication, bilge, and sanitary pumps will be built as a separate unit and will be chain driven—see plan Fig. 3. According to the makers, the total weight of this unit is 140 tons less than for a similar outfit with reciprocating engines.

Shop trials of this unit have been carried out by Professor C. J. Hawkes, and the bulk of his report is reprinted below.

REPORT BY PROF. C. J. HAWKES.

At the request of the Parsons Marine Steam Turbine Company, Ltd., Turbinia Works, Wallsend-on-Tyne, I supervised a series of trials of their "Simplex" turbine unit at the works on November 14th, 16th, and 17th, 1934. The principal object of these trials was to ascertain the steam consumption of the turbines over a range of powers. The nominal full power of the unit is 2000 b.h.p. at 80 r.p.m.

BRIEF DESCRIPTION OF THE ENGINE.

The unit (Fig. 2) consists of two turbines, h.p. and l.p., working in series. The h.p. ahead turbine is of the impulse-reaction type, consisting of two impulse velocity stages and three reaction expansions fitted with end-tightened blading. The l.p. ahead turbine is of the ordinary reaction type with fourteen expansions. The turbines drive, through expansion couplings, a common primary pinion gearing with a primary reduction wheel. The secondary piston, which is on the same shaft as the primary reduction wheel, drives the main wheel, which is directly connected to the brake shaft. When the brake shaft speed is 80 r.p.m. the speed of the turbines is 3993 r.p.m., i.e., the total reduction is about 50 to 1. The gearing is of the single helical type, with involute teeth; and thrust blocks are fitted to each turbine, to the primary pinion, to the intermediate gearing shaft, and to the main shaft. The end thrust of the main gear wheel will, in practice, be opposed to the propeller thrust, which will reduce the load on the main thrust block.

For astern working a h.p. astern impulse wheel is incorporated in the h.p. ahead turbine casing, working in series with a l.p. astern impulse wheel situated in the exhaust casing of the l.p. ahead turbine.

The condenser is of the three-pass type and it is mounted with the turbines on the gear case, making a very compact arrangement.

During the trials saturated steam was supplied by an oil-fired Babcock and Wilcox boiler, and the steam was then superheated in a separate oil-fired superheater. The boiler, which was recently installed, is capable of generating 40,000 lb. of saturated steam per hour at a pressure of 600 lb. per square inch, and the superheater can raise the steam temperature to 850 deg. Fah. The main steam pressure to the turbines was controlled by a stop valve placed in the pipe line at the point where it entered the testing bay from the boiler-house.

A special auxiliary unit—comprising the circulating, condensate, forced lubrication, bilge, and sanitary pumps—has been designed which will be embodied in the "Simplex" unit at a later date. This auxiliary unit will be driven by chain drive and friction clutch from the main wheel shaft when the turbines are running at full power ahead, and by an auxiliary steam engine, through a friction clutch, under all other conditions. With this arrangement a three-stage air ejector will be used. The auxiliary unit was not in use during the trials; and the three-stage air ejector and condensate pump were replaced by a single-stage augmentor and a Weir's monotype air pump. Steam circulating and forced lubrication pumps were employed. The steam pumps were supplied with saturated steam and they exhausted to a winch condenser. The steam consumption of these auxiliaries is not recorded.

Saturated steam was admitted as necessary to the turbine glands, and all the turbine drains were led to the condenser.

It is understood that the plant was built in accordance with the requirements of Lloyd's Register of Shipping and the British Corporation.

METHODS OF MEASUREMENT EMPLOYED.

Steam Consumption.—The air pump discharge—which consisted of the condensate from the turbines, from the turbine glands, and from the augmentor—was led to the measuring tanks. Two tanks were employed, each capable of holding about 650 gallons of condensate. The tanks, which were fitted with the necessary change-over supply and drain cocks, were calibrated before the trials at a temperature of 45 deg. Fah. The temperature of the water entering the measuring tanks was recorded during the trials, and the slight adjustments necessary on account of temperature have been included in the recorded results.

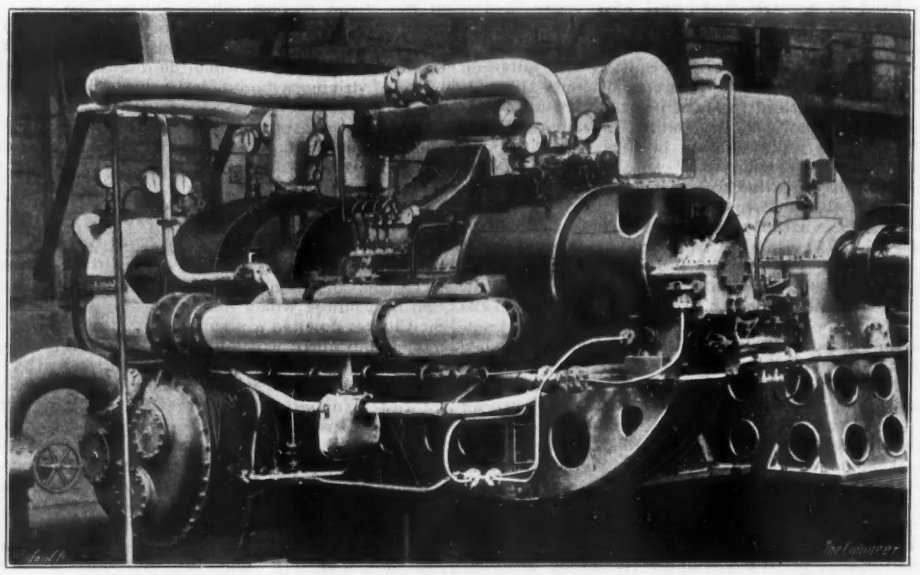


FIG. 1—2000 S.H.P. GEARED TURBINE UNIT

The diameter of the steam nozzle of the augmentor was $\frac{1}{16}$ in. The steam pressure to the augmentor was practically constant throughout the trials at 100 lb. per square inch, and at this pressure the calculated steam consumption is nearly 120 lb. per hour. As it was desired to measure the steam consumption of the turbines only, the estimated steam consumption of the augmentor has been deducted from the measured condensate.

Brake Horse-power.—The b.h.p. developed by the turbines was absorbed by a Heenan and Froude hydraulic dynamometer of the compound lever type coupled to the main gear wheel shaft. The procedure followed was to set the brake load at the figure fixed for the particular trial and then adjust the turbine steam and the brake valves as necessary during the stabilising period in order

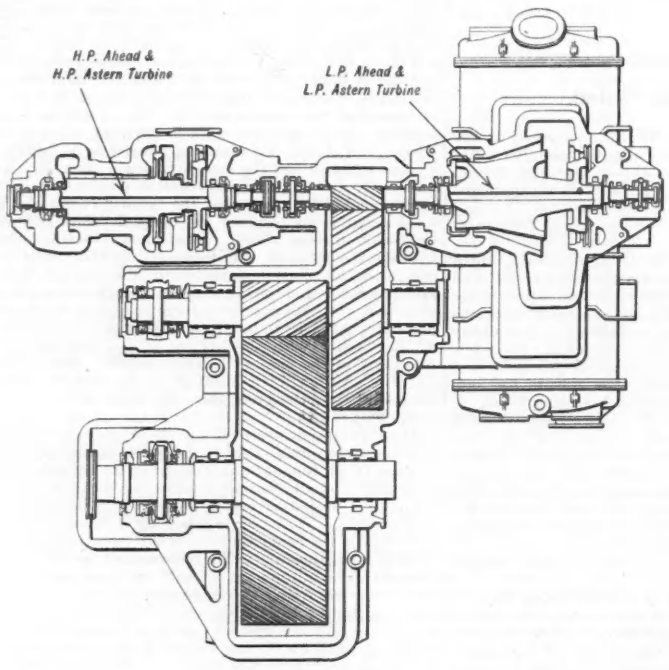


FIG. 2—COMPLETE TURBINE UNIT

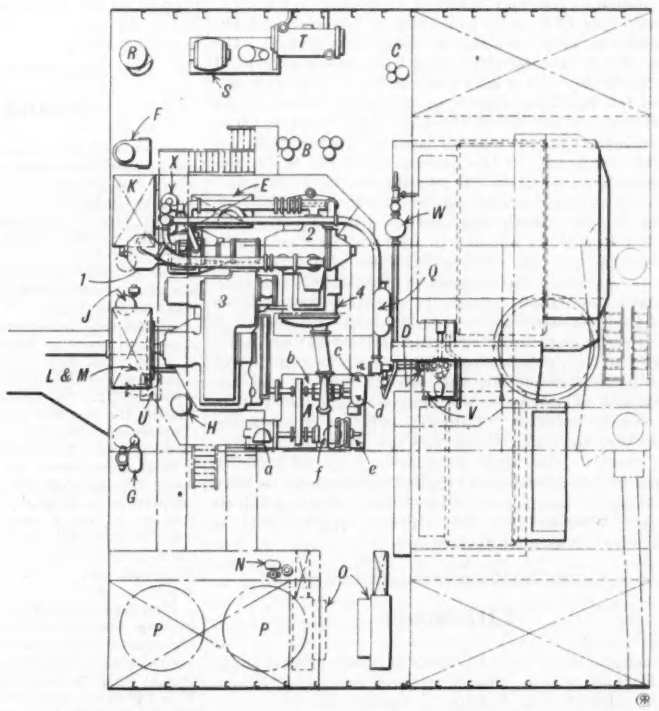


FIG. 3—COMPLETE INSTALLATION IN CARGO STEAMER

LEGEND FOR FIG. 3

1.—H.p. ahead and h.p. astern turbine.
2.—L.p. ahead and l.p. astern turbine.
3.—Reduction gearing.
4.—Condenser.
A.—Auxiliary unit:
a.—Engine.
b.—Circulating pump.
c.—Extraction pump.
d.—Main forced lubrication pump.
A.—Auxiliary unit (*continued*):
e.—Sanitary pump.
f.—Bilge pump.
B.—Main feed pump.
C.—Auxiliary feed pump.
D.—Feed heaters.
E.—Filter tank.
F.—Ballast pump.
G.—Auxiliary forced lubrication pump.
H.—Forced lubrication oil cooler.
J.—Forced lubrication purifier.
K.—Forced lubrication storage tank.
L.—Forced lubrication gravity tank.
M.—Forced lubrication reserve tank.
N.—Oil fuel transfer pump.
O.—Oil fuel burning units.
P.—Oil fuel settling tank.
Q.—Air ejector.
R.—Evaporator.
S.—Generator.
T.—Auxiliary condenser and drain collector.
U.—Turning engine.
V.—Fan engine.
W.—De-superheater.
X.—Manœuvring gear.

to balance the brake at the revolutions previously decided upon.

Trials.—It was decided to carry out trials at the full rated power of 2000 b.h.p. at 80 r.p.m., and at 2300 b.h.p., 1750 b.h.p., 1500 b.h.p., 1250 b.h.p., and 1000 b.h.p., the

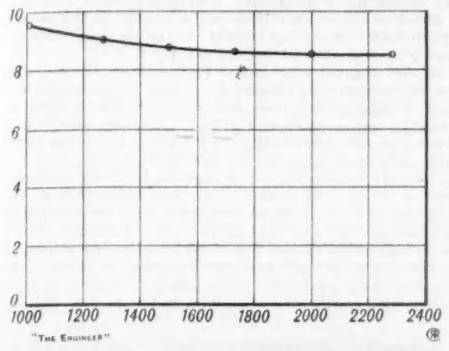


FIG. 4—STEAM CONSUMPTION: POUNDS PER B.H.P. HOUR AT VARIOUS LOADS

respective brake loads and r.p.m. being calculated according to the usual propeller law. Preliminary tests had shown that when conditions had settled, and the temperatures and pressures were steady, trials of 1½ hours' duration were quite sufficient to give reliable records of the steam consumptions. The steadiness of the readings during the trials is clearly indicated in this report.

There are nine nozzles in the h.p. ahead turbine, in groups of four, three, and two, and each group is controlled by a valve. During the overload trial No. 1 seven nozzles were in use with the control valves full open, and the control valve to the remaining two nozzles was shut. The main steam pressure was about 270 lb. per square inch. The same combination was in use for trial No. 2, at the rated power of 2000 b.h.p. at 80 r.p.m., but the

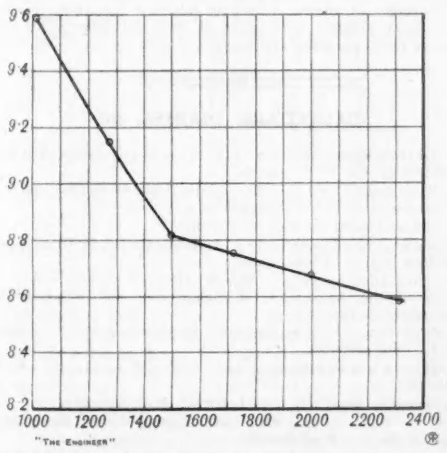


FIG. 5—STEAM CONSUMPTION: POUNDS PER B.H.P. HOUR AT VARIOUS LOADS

main steam pressure was reduced to about 235 lb. per square inch. For the remaining trials the steam pressure was maintained at about 260 lb. per square inch and the nozzles in use were as follows:—

Trial No. 3—Four nozzles, control valve wide open;
Two nozzles, control valve partly closed;
Three nozzles, shut off.

Trials Nos. 4, 5, and 6—

Three nozzles, control valve wide open;
Two nozzles, control valve partly closed:
Four nozzles, shut off.

Throughout the trials the steam leakage from the glands of the turbine was, for all practical purposes, negligible, and there were no other leaks of any kind.

Mean Observations Derived from Log Sheets.—A summary of the principal results are given in Table I.

Deductions.—The deductions are given in Table II. In calculating the efficiency of the plant, for the turbines only, the heat content of the steam has been reckoned from the temperature of the condensate in the wet air pump suction. Similarly, in the calculations for the efficiencies of the turbines and the "standard of comparison" the heat content of the steam at the stop valve, obtained from Callendar's Revised Steam Tables, has been reduced by the heat content of the water at the temperature corresponding to the pressure at the exhaust flange.

A curve showing the steam consumptions on a b.h.p. base is given in Fig. 4. A similar curve, but with a very open scale for the steam consumptions, is given in Fig. 5. It will be seen that the curve of steam consumption for the unit as tested really consists of two curves, one connecting trials Nos. 1, 2, 3, and 4, and one connecting trials Nos. 4, 5, and 6. The difference in the slopes of the two curves is probably due to some extent to the nozzles in use, and the pressures in the nozzle boxes for the various trials. It will be observed that whilst the steam pressures in the nozzle boxes were well maintained during trials Nos. 1 to 4, by varying the number of nozzles in use no further variation was possible after trial No. 4; consequently the power developed by the turbines during trials Nos. 5 and 6 had to be controlled by reducing appreciably the steam pressure to two nozzles. The average pressure in the box supplying the two nozzles, for example, was only 40 lb. per square inch during trial No. 6.

The recorded steam consumptions of the plant are exceedingly good, and it will be seen from the curves that there is little falling off in the efficiency of the turbines at the lower powers. As a result of the trials the firm proposes to modify the blading at the exhaust end of the l.p. turbine, which, it is anticipated, will have the effect of reducing slightly the steam consumption of the plant at the higher powers.

The plant, which was under my constant supervision, ran smoothly and steadily throughout the trials, without an incident of any kind. C. J. HAWKES.

November 28th, 1934.

TABLE I.—*Summary of Powers and Steam Consumptions.*

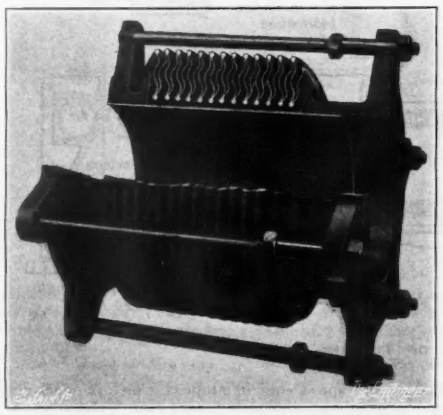
Trial number	1	2	3	4	5	6
Date, 1934	14/11	14/11	16/11	16/11	17/11	17/11
Commencement of trial	2.1 p.m.	4.5 p.m.	1.46 p.m.	4.8 p.m.	10.48 a.m.	1.13 p.m.
Duration, minutes	90	90	90	90	90	90
Brake load, lb.	8,319	7,537	6,893	6,222	5,510	4,746
Average r.p.m. of brake shaft	83·75	79·76	76·36	72·47	68·89	63·77
B.h.p.	2,323	2,094	1,754	1,503	1,265	1,009
Steam consumption, turbines only, lb. per hour	20,006	17,400	15,360	13,254	11,572	9,678
Steam consumption, turbines only, lb. per b.h.p. per hour	8·61	8·68	8·75	8·82	9·16	9·6

TABLE II.—*Deductions.*

Trial number	1	2	3	4	5	6
Steam pressure, lb. per sq. in. abs.	283·6	249·7	272·8	276·8	277·8	279·8
Steam temperature, deg. Fah.	759	762	768	760	756	763
Vacuum, l.p. exhaust, inches of Hg.	28·49	28·65	28·76	28·9	28·97	29·09
Condensate temperature, deg. Fah.	75	73	72	70	71	67
Steam consumption, turbines only, lb. per b.h.p. per hour	8·61	8·68	8·75	8·82	9·16	9·6
Heat content of steam from condensate temperature, B.Th.U. per lb.	1,360	1,365	1,368	1,366	1,364	1,371
Thermal efficiency of plant (turbines only) based on heat content of steam from condensate temperature, per cent.	21·7	21·5	21·3	21·1	20·4	19·3
Heat content of steam from l.p. exhaust temperature, B.Th.U. per lb.	1,344	1,350	1,355	1,354	1,355	1,362
Thermal efficiency of turbines, per cent.	22	21·7	21·5	21·3	20·5	19·5
Available heat between stop valve and exhaust, B.Th.U. per lb.	462	462	472	477	481	488
Efficiency of standard of comparison per cent.	34·4	34·2	34·8	35·2	35·5	35·8
Efficiency ratio of turbines, per cent.	64	63·4	61·7	61·5	57·7	54·4

Concertina Expansion Joints.

WE illustrate herewith a new form of expansion joint for steam pipes, which is being put on the market by Mr. O. N. Beck, of 11, Queen Victoria-street, London, E.C.4. It is, it will be seen, of the concertina or bellows



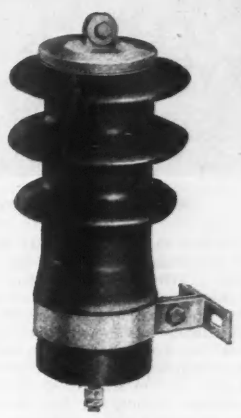
CONCERTINA EXPANSION JOINT

type, which is familiar, but has in the past generally been made of rounded corrugations in copper. In the present instance, however, the flexibility of the joint is provided for by a number of dished steel discs, which are welded together by fusion, in specially designed machines, at their inner and outer circumferences. The material is a nickel alloy steel, and the welds are said to be made both ductile and flexible by subsequent heat treatment. They are, of course, steam tight.

The principle of the device needs no explanation, but it may be mentioned that we have known of a case where ½ lb. per square inch of steam pressure was saved by substituting a continuous-flow expansion joint for one of the old-fashioned, double S bends, while the concertina arrangement produces no appreciable resistance to the expansion and contraction of the piping. It will be noticed that a sliding sleeve is provided inside the joint to prevent eddy losses. These joints are made in a variety of sizes from 2in. bore up to 15¾in. bore, and have an expansion capacity of $^{3}/_{32}$in. per single element of the bellows in the 2in. size, up to $^{9}/_{64}$in. for the largest size. The outside diameter in the medium sizes is about double the bore. The joints have been tested up to pressures of 18 atmospheres.

Lightning Arresters.

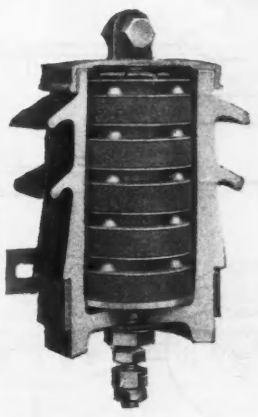
STORMS in various parts of the country during the past summer emphasised the necessity of providing overhead transmission lines with arresters to dissipate dangerous over-voltages caused by lightning in order to prevent damage to transformers and other apparatus. For low-voltage lines standard arresters are available to meet all conditions likely to be encountered including switching surges; but partly owing to the greater difficulty of preventing a flow of current to earth when the surge has been relieved, the problem of designing arresters for high-voltage circuits is more complicated. Many lightning arresters for high pressures have, of course, been devised, and one of the latest produced in this country



LIGHTNING ARRESTER

is an arrester developed by the General Electric Company, of Magnet House, W.C.2. It consists of resistance blocks and spark gaps arranged in series, and housed in a sealed container with fixing clamps for attachment to transmission poles or sub-station structures. The resistance discs are composed of ceramic compound, and since the flat surfaces are metallised with copper, a perfectly uniform contact is provided between the discs. As the voltage rises, the conductivity increases much more rapidly than the voltage and the variation takes place instantaneously.

The complete spark gap is made up of a number of small gaps in series, each situated between adjacent resistance blocks, and set to arc over at twice the normal



CONSTRUCTION OF LIGHTNING ARRESTER

voltage, an arrangement which provides greater breakdown capacity than a single gap of equivalent capacity, and thus allows a lower value of resistance to be used. Each gap between adjacent resistance blocks actually consists of four gaps in parallel, thus providing a high discharge capacity, and enhanced durability without danger of pitting. To reduce the time lag the gaps are formed of well-rounded domes, which give an impulse ratio of practically unity. Steatite distance pieces accurately ground and located in a small recess in the resistance block form the gap spacers. The arrangement is virtually non-inductive, which is an essential feature.

At normal voltage the arrester is practically an insulator, and, consequently, no current flows through it; but at a predetermined higher voltage the gaps break down and the resistance falls rapidly, thereby allowing current to flow through the resistance blocks to earth. The higher

the excess voltage the greater is the current passed by the arrester. If, for instance, the voltage is doubled, the current is increased about ten times, so that surges are quickly discharged. As the over-voltage is relieved and the pressure falls, the resistance increases very rapidly, and finally the spark gaps interrupt the current and the arrester then becomes an insulator again capable of withstanding the normal working pressure. The resistance blocks are liberally rated, will withstand repeated discharges without overheating, and will not, it is claimed, puncture on the severest discharge.

To demonstrate the performance of this type of arrester severe tests were recently carried out in the presence of representatives of the Central Electricity Board, power companies, and consulting engineers at the G.E.C. high-voltage laboratory, Witton, Birmingham. A million-volt surge was first applied to a line supported by a standard 6600-volt insulator, which naturally flashed over. An "M G" type arrester, as shown in the accompanying illustrations, was then connected to the line, and when the surge was again applied it was immediately discharged without a flash-over on the arrester or on the insulator. A klydonogram taken during the test showed that the voltage only rose to a peak value of 16,000. During the latter test a 6600-volt supply was connected to the circuit, and it was demonstrated that no power current measurable by an ordinary instrument followed the arc to earth, whilst an oscillograph record showed that the current in the arc was cut off in about 0·005 second. Arresters differing only in the number of resistance blocks they contain are available in various sizes and suitable for three-phase systems with the neutral insulated or earthed through a resistance, or for single-phase systems. The full range is as follows :—

Volts.		Volts.		Volts.	
250	D.C. and A.C.	2,200	A.C.	11,000	A.C.
600		3,300		22,000	
1,100	A.C.	6,600		33,000	

The illustrations show the internal construction of an arrester and its external appearance.

Vacuum Power Locomotive Turning Gear.

A TURNTABLE operated by power derived from the vacuum or air brake system of a locomotive was put to work four months ago by Cowans, Sheldon and Co., Ltd., of St. Nicholas Works, Carlisle, at the King's Cross locomotive department of the London and North-Eastern Railway Company, and since its installation has been in continuous and successful operation.

The patented system illustrated herewith was first fitted to the 70ft. diameter balanced turntable at King's Cross in the form of the self-contained tractor and two vacuum accumulator cylinders shown in Fig. 1, but a modified design has also been constructed which can quite well be incorporated in the hand-operating gear of an articulated turntable, such as the Vogele type table, which is manufactured by Messrs. Cowans, Sheldon, under licence. In this case the motor is directly connected to one of the end wheels of the table. The actuating motor is shown in Fig. 2. It consists of two double-acting oscillating cylinders, which drive a crank shaft carrying a pinion which meshes with the gearing driving the travelling wheel.

Attention may be drawn to the very simple method of reversing and speed control adopted, which in effect gives single lever operation with a "dead-man" characteristic. The chamber between the two oscillating cylinders is divided horizontally and reversing is obtained by the four valves arranged at the end of the chamber, which, alternatively, open the top and bottom passages or ports to atmosphere pressure or vacuum respectively.

The pistons, which have a diameter of 4¼in. and a stroke of 6in., are made in a light alloy, and their lubrication is effected by a soft packing ring, the oil supply to the ring being from time to time replenished through nipples at the bottom and top of the piston. Easy access to the cylinder oiling nipples is obtained through hinged cylinder covers, which are held in position by a spring-controlled cross bar and are easily swung open for oiling and inspection. The piston-rod glands are furnished with locomotive pattern oil cups, while the trunnions and crank shaft bearings are of the ball or roller type and require only occasional lubrication. Emergency hand gear can be fitted to the tractor by fixing a handle to the second motion shaft. A general view of the tractor unit, with the gearing covers removed, is shown in Fig. 3.

On the occasion of a visit to King's Cross, the machine was demonstrated by turning a "Pacific" type engine and tender weighing close upon 150 tons in about 1¼ minutes. When the engine had been run on to the table, the vacuum brake pipe was connected to the stand pipe on the turntable, arranged near the tractor unit—see Fig. 1—and the vacuum ejector started up and run for a few moments until a vacuum of about 15in. was registered in the accumulator system, which consists of two steel cylinders attached one on either side of the table. During the turning operation the ejector was maintained in operation and by the end of the run the vacuum had, we noted, only fallen to about 12in. The table can quite well be turned, we were informed, with a vacuum as low as 5in. Should it be required to turn a dead locomotive, the necessary degree of vacuum is always available from the accumulator cylinders, and there is sufficient vacuum power left to return the table to the original position. We were impressed by the simplicity of the motor and its control gear, and the ready way in which by moving the control lever either forward or backward the table could be "inched" into the final locking position. To test out-of-balance turning, the "Pacific" type locomotive was, in our presence, placed purposely right out of balance, and was in this position easily turned by vacuum power, whereas for hand turning the services of four or six men would have certainly been required. The increasing use of larger and heavier locomotives calls for some power-operated system of turning, for which vacuum or air brake power is admirably suited. By using a form of power which is inherent to every locomotive and is free from the disadvantages of steam, a step in advance has been made which, we suggest, will prove of material interest to all locomotive operating engineers and railway authorities.

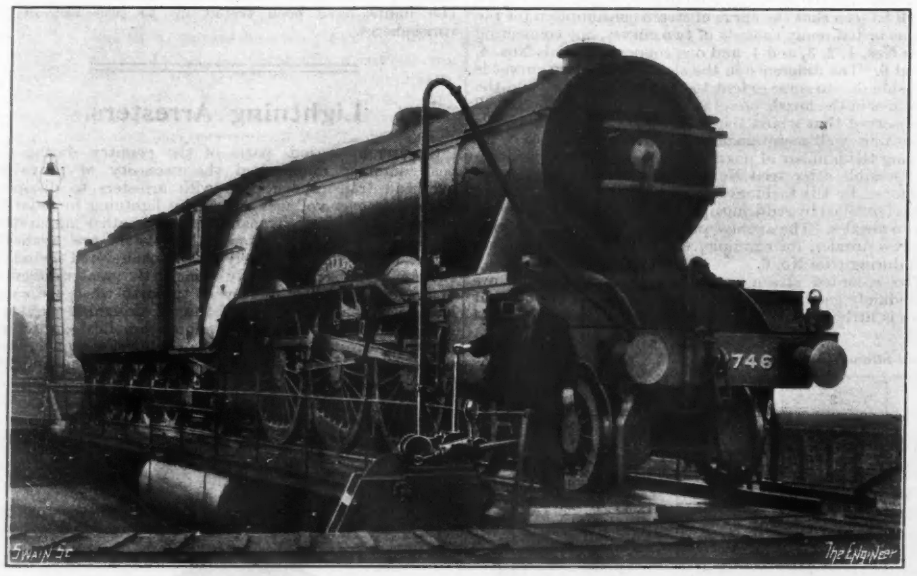


FIG. 1—VACUUM POWER TURNING GEAR FITTED TO TURNTABLE

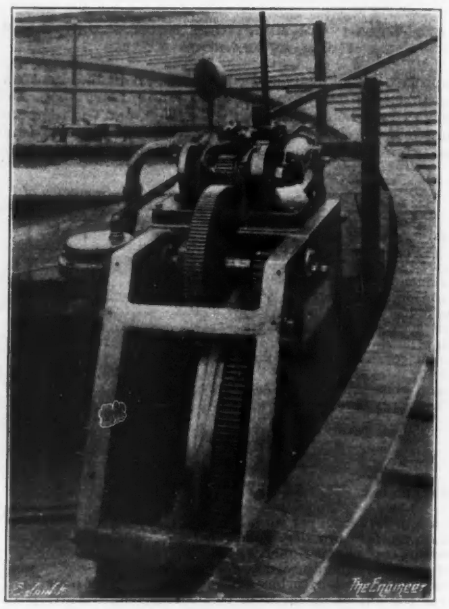


FIG. 3—TRACTOR UNIT WITH GEAR COVERS REMOVED

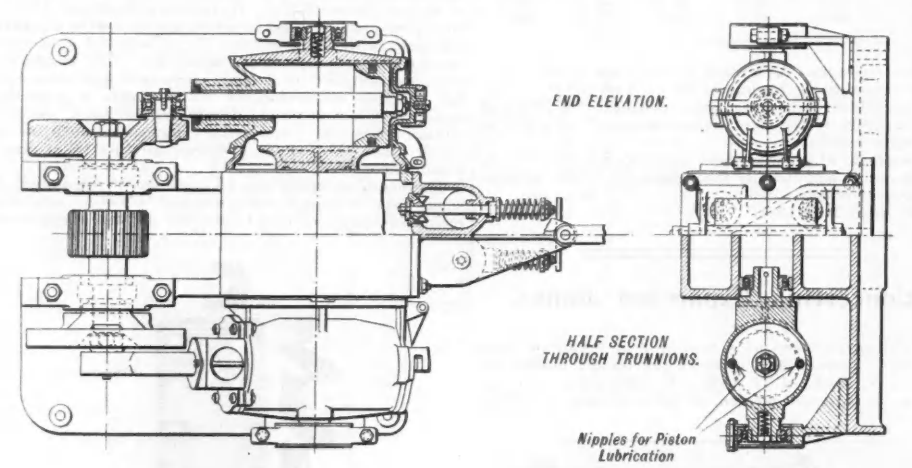


FIG. 2—ACTUATING MOTOR OF TURNING GEAR

CALENDARS, DIARIES, &c.

WILLIAM BAIRD AND SON, Ltd., Temple Ironworks, Annesland, Glasgow.—Wall calendar.

BRAITHWAITE AND CO., ENGINEERS, Ltd., Horseferry House, Westminster, S.W.1.—Pocket diary.

DEMAG, Duisburg.—Calendar refill.

DORMAN, LONG AND CO., Ltd., Terminal House, 52, Grosvenor-gardens, S.W.1.—Pocket diary.

"THE DRAUGHTSMAN," 96, St. George's-square, S.W.1.—Copy of the Association of Engineering and Shipbuilding Draughtsmen Diary.

EVERSHED AND VIGNOLES, Ltd., Acton-lane Works, Chiswick, W.4.—Wall calendar.

GREENWOOD AND BATLEY, Ltd., Albion Works, Leeds.—Wall calendar.

IMPERIAL AIRWAYS, Ltd., London.—Wall calendar.

C. A. PARSONS AND CO., Ltd., Heaton Works, Newcastle-upon-Tyne, 6.—Wall calendar.

GEORGE REVEIRS, Ltd., 10–12, Rosebery-avenue, E.C.1.—Greeting card.

THOMAS ROBINSON AND SON, Ltd., Rochdale.—Wall calendar.

ANDREW CARNEGIE RESEARCH FUND.—The Council of the Iron and Steel Institute makes annually a limited number of grants from the Research Fund founded by the late Mr. Andrew Carnegie in aid of metallurgical research work. The object of the scheme is not to facilitate ordinary collegiate studies, but to enable students, who have passed through a college curriculum or have been trained in industrial establishments, to conduct researches on problems of practical and scientific importance relating to the metallurgy of iron and steel and allied subjects. Candidates, who must be under thirty-five years of age, must apply before the end of next January on a special form to be obtained from the Secretary of the Institute, 28, Victoria-street, S.W.1. The value of the grant will depend on the nature of the proposed research work, but the maximum amount granted in any one year will, as a rule, not exceed £100.

Air Swirl in Oil Engines.*

By J. F. ALCOCK, B.A., A.M.I. Mech. E.†

SWIRL, or rotational motion of the air charge within the combustion chamber, has long been used in oil engines as a means of effecting fuel distribution, but recently its use has spread rapidly, more particularly in the small high-speed engine. In spite of this, little is as yet on record as to the principles of its production and utilisation, and the object of the present paper is to remedy this.

Air movement is needed both in petrol and in oil engines; but there is this important difference, that in the ready-mixed charge of the petrol engine the duty of the air flow is to scatter the flame nuclei, whilst in the oil engine charge the temperature is everywhere high enough to effect ignition wherever the fuel and air come together, and the duty of the air movement is to bring them together. For this is needed an ordered movement, a planned economy

FIG. 1.

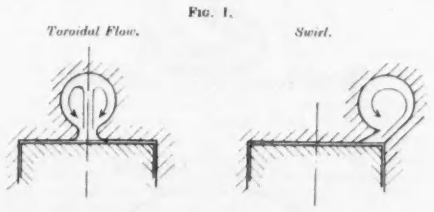
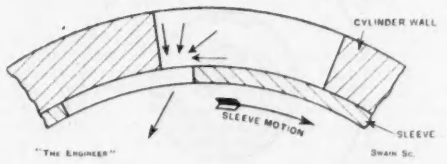


FIG. 2.—*Oblique Inflow in single-sleeve valve engine.*



as against the indiscriminate turbulence which suits the petrol engine.

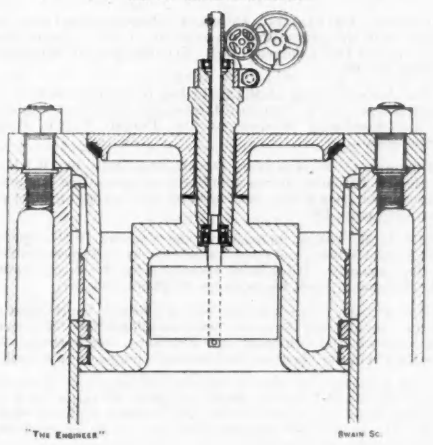
The reason for this difference is that with general turbulence each particle travels in an irregular path and often returns on its track. With a flame nucleus this does not matter; it has handed on the torch and its work is done. With a fuel spray the case is different. The smaller particles which ignite first will, if they remain near their heavier neighbours, merely blanket them with burnt gas; it is no use taking them for a short circular tour—they must be swept right out of the way.

Since the piston motion during combustion is small, rotation in a closed path is the only possible form of air flow. There are two main types, toroidal or vortex ring motion, and "swirl" or rotation about a linear axis. Fig. 1, showing two well-known arrangements, clearly illustrates this distinction.

There are three methods of swirl production:—

(1) Induction swirl, produced by oblique air inflow to the cylinder during the induction stroke (or scavenge period in the case of two-stroke engines). The obliquity

FIG. 3.—*Ricardo Swirl Meter.*



of flow is generally produced by an inlet valve shroud in four-cycle engines, such as the Hesselman, and by oblique scavenge ports in two-cycle engines, such as the Junkers. A special case is the four-cycle single sleeve valve engine, in which the asymmetrical form of the inlet orifice, during the earlier part of the suction stroke, gives the flow a large tangential component, as shown in Fig. 2.

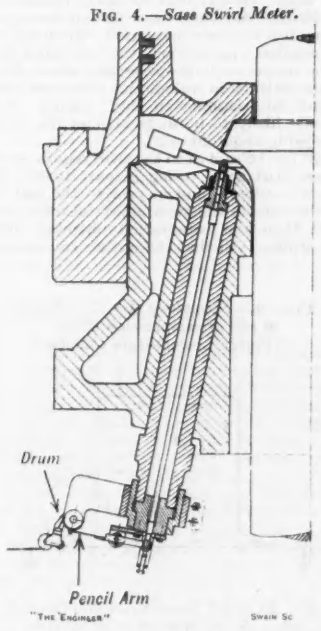
(2) Compression swirl, produced during the compression stroke by forcing the charge through a restricted passage, as in Fig. 1. This is a very popular type, including the Lister, Ricardo "Comet," and Thornycroft systems.

(3) Combustion swirl, produced by the combustion and consequent expansion of part of the charge. The Lanova engine is the only one using this principle.

Swirl Measurement and Notation.—For the measurement of swirl two methods are available. The first uses a freely rotating vane within the combustion chamber, carried on a spindle which passes through the sealing gland to an external counting mechanism (Fig. 3). The vane speed is measured while the engine is motored. It is obvious that the observed speed is not the swirl at the end of the compression stroke, which is what matters, but some kind of a mean of the swirl during the entire cycle. The two values, however, appear to be in some roughly constant relationship, since it is found that different engines with similar combustion arrangements all require much the same swirl rates as measured by this method.

The other method is to measure the force exerted by the "wind" on a fixed vane. This method is described in Dr. Sass's "Kompressorlose Dieselmaschinen," from which book, by its author's courtesy, Figs. 4 and 5 are reproduced. Fig. 4 shows the apparatus as used on a large low-speed engine, comprising a light vane carried by a radial arm on a spindle which passes

FIG. 4.—*Sass Swirl Meter.*



through a gland and actuates a pencil working on an indicator drum. This method has two important advantages: the first that it can be used, as the rotating vane method cannot, in cases where the swirl axis is occupied by a piston-rod or other obstruction, and the second that it gives an indication of the swirl variations during the cycle—Fig. 5. On the other hand, it is difficult to allow for the swirl-reducing effect of the fixed vane, and the inertia of the moving parts would affect the indications at high engine speeds.

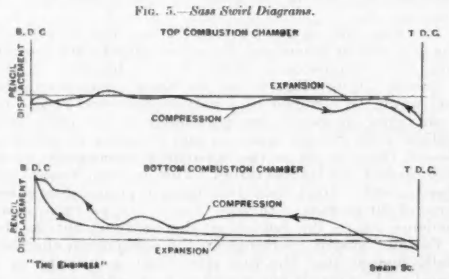
In addition to their use on motored engines, both methods can be employed on stationary models, air being blown through the inlet ports from an external source. In these "blowing tests" the freedom of experiment is, of course, far greater than in motoring tests on an actual engine, and they have proved very useful in studying the mechanism of swirl production, but the author has as yet found no reliable method of deducing motoring swirl rates from blowing test figures on four-stroke engines at any rate.

As regards swirl rotation, it will be shown later that most engines both produce and require a rate of swirl rotation which is roughly a constant multiple of the engine speed. It follows, then, that the swirl intensity is best expressed as the ratio of these two speeds. This ratio is called the "swirl ratio."

Swirl Utilisation.—Having obtained swirl by one means or another, the next question is how to make use of it. In this respect swirl type engines may be roughly divided into three classes, high swirl, medium swirl, and low swirl, though there are, of course, borderline cases.

High Swirl Engines.—High swirl engines are characterised by combustion chambers of small diameter and single jet injectors. The reason for this combination is that a high swirl ratio is more easily provided in a chamber of small diameter, since for a given linear velocity the speed of

FIG. 5.—*Sass Swirl Diagrams.*



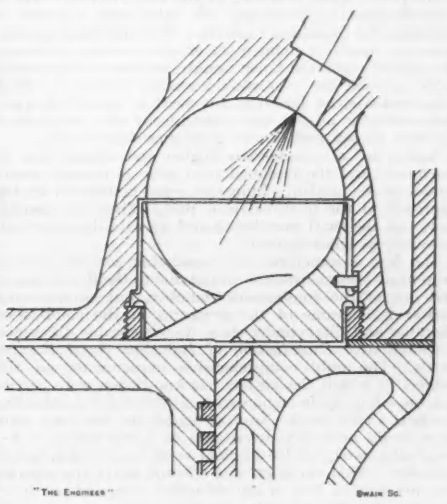
rotation is increased by reducing the circumferential path, and this high swirl ratio enables a good performance to be obtained with a single jet, a valuable simplification in small engines.

Most engines of this class are of the compression swirl type with a combustion chamber either spherical or cylindrical, with a single diametral fuel jet, as in Fig. 6. Variants are the Perkins engine, with its tangential fuel jet from an injector located on the throat, and the Ricardo "Vortex" type—Fig. 7—in which the single fuel jet lies close to the side wall of the cylindrical combustion chamber.

As regards performance, the main characteristic of high swirl systems is their ability to burn efficiently a large proportion of the total air charge, a figure of 80–85 per cent. at the clean exhaust limit being possible with careful design. This results in a high clean exhaust output and low fuel consumption at high loads. The better specimens of all types of engine that the author has tested, from the non-swirl through intermediate types to the high swirl, all give an absolute maximum indicated mean effective pressure, with coal-black exhaust, of 140–155 lb. per square inch, but the clean exhaust limit is rarely above 110 lb. per square inch in the non-swirl type (pre-combustion chamber engines excepted), while in high swirl engines it is usually about 130–140 lb. per square inch and 145 lb. per square inch has been recorded. In one extreme case within the author's experience the mean effective pressures at the absolute maximum and at the clean exhaust limit differed only by 0·5 lb. per square inch.

Another characteristic of high swirl systems is their insensitiveness to changes in injection conditions, such as nozzle size and rate of injection, which contrasts strongly

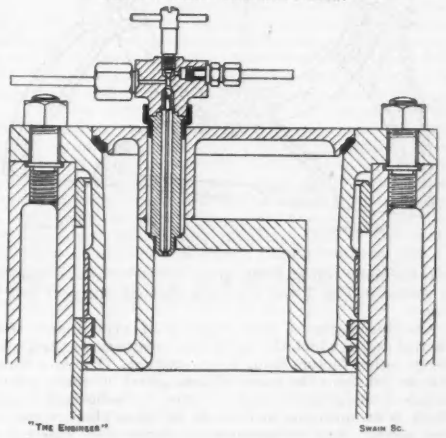
FIG. 6.—"*Comet*" *Combustion Chamber.*



with the extreme sensitiveness of the non-swirl type. Owing to this, nozzle erosion, pump plunger wear, &c., have comparatively little effect. Another consequence is that with the high swirl types, the initial troubles of a new design are generally mild, whereas the author's experience of small non-swirl engines is that one can never rely on two engines behaving alike. One likely reason for this is that most "non-swirl" engines probably rely on air flow, as an aid to distribution, to a greater extent than their designers realise, and that this air movement is liable to be affected by small changes in inlet passages, &c., such as may be caused by core displacements.

The price paid by the high swirl system for its advantages is very moderate. The chief item in the bill is a greater difficulty in starting, due to the heat loss from the swirling air during slow compression in a cold cylinder. In theory the high air velocity should cause increased heat loss, and therefore loss of efficiency, during normal running, but high swirl engines have attained efficiencies quite as high as the non-swirl type. This appears to be due in part

FIG. 7.—"*Vortex*" *Combustion Chamber.*



to improved combustion efficiency which offsets the heat loss, and in part to the fact that injection and combustion break up the organised air movement, so that little survives into the expansion period when the heat losses mainly occur.

Medium Swirl Engines.—The most common type in this class has a fairly shallow combustion chamber, the full diameter of the cylinder, or nearly so, and two or more injectors spraying inwards. This system is, for obvious reasons, very popular in opposed-piston engines.

Low Swirl Engines.—The most common of these is that with a shallow combustion chamber and a central injector, with multiple radial jets, the classic Hesselman type. This is really the orthodox "non-swirl" type enlivened by the addition of a little swirl. It is very hard to draw the line between the two types, for a tangential inlet bend, as used on most "non-swirl" engines for mechanical reasons, gives a certain amount of swirl.

The characteristics of the medium and low swirl types are intermediate between those of the non-swirl and high-swirl engines. A few of the better specimens, as, for example, the Junkers aero-engine and the Gardner road vehicle engine, attain the high output of the high-swirl engine, but at the cost of mechanical drawbacks, such as multiple injection orifices and high injection pressures. On the other hand, they have the easy starting that is characteristic of the non-swirl type.

Comparison of Induction and Compression Swirl Systems.

* The Institution of Mechanical Engineers, December 14th.—Abstract.

† Personal assistant to technical director, Messrs. Ricardo and Co.

—The chief drawback of the induction swirl system is the difficulty of obtaining a high swirl rate in four-cycle poppet valve engines. This has limited its use in vehicle engines, which are generally of this type, and for this class of work compression swirl has the immense advantage that by thermal insulation of the oblique throat, as shown in Fig. 6, the charge can be heated to a very high temperature during compression. This ensures prompt and complete combustion, giving smooth running and a clean and odourless exhaust. The price paid for these advantages is a small increase in fuel consumption due to heat loss from the gas flowing out at high velocity through the throat during expansion, and a more difficult start due to heat loss to the initially cold throat during compression.

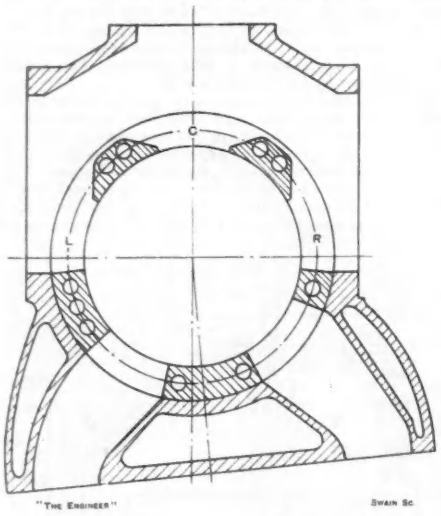
Another advantage of compression swirl is its independence of the induction system. With induction swirl it becomes increasingly difficult to provide adequate swirl as the piston speed is raised, for the inlet velocity must be kept constant by increasing the valve area in order to maintain the breathing capacity. Thus the swirl revolutions per minute remain more or less constant although the engine revolutions per minute increase, whereas the ratio between the two should remain constant. With compression swirl, however, the swirl is controlled, quite independently of the inlet system, by the combustion chamber throat, and can be given any desired value.

Again, in a compression engine the throat can be machined, and the designed swirl ratio is thereby maintained in production. Induction swirl is affected by the approach to the inlet valve or port. These are usually cast, and the swirl may be altered by core displacement, especially in small engines.

The fear is sometimes expressed that serious pressure drop must occur across the throat due to the flow of gas in and out of the combustion chamber, but simultaneous indicator diagrams of the pressures in the combustion chamber and the cylinder show no measurable difference.

Quantitative Examination of Induction Swirl Requirements.—The only comprehensive experiments on this subject of which the author has knowledge were carried out on a four-cycle engine with a "Vortex" combustion system. This engine was designed so that the swirl ratio could be varied from zero to a maximum of 6·3 "cylinder swirl," or 16·3 "final swirl" in the combustion chamber. This variation was effected partly by altering the direction of flow in the induction belt, and partly by the use of baffles outside the inlet ports. Air measurements showed that these expedients did not have any measurable throttling effect, so that the observed changes in performance are due solely to combustion effects. The engine had a single cylinder, 5¼in. bore by 7in. stroke, and

FIG. 8.—*Experimental Sleeve Valve Engine, section through ports.*



was normally run at 1300 r.p.m. Its combustion chamber is shown in Fig. 7 and a section through the port belt in Fig. 8.

On this engine a large number of experiments were carried out in which the swirl ratio was varied over a wide range, other factors being kept constant. The fact which stands out from the mass of data given by these experiments is this, that for the "Vortex" combustion system there is an optimum swirl ratio which is characterisic of the system, and independent of engine size, speed, and load. There is not as yet any direct evidence that the same rule applies to other combustion systems, but there is a fair amount of indirect evidence that it does apply, approximately at least, to some other high-swirl systems. The main item of this evidence is that high-swirl engines generally give a good performance over that speed range within which one would expect the swirl ratio to remain constant. Thus it may be that every swirl type combustion system has its characteristic optimum swirl ratio, but the existing data are not enough to justify a definite generalisation.

There are, too, some exceptions. With the "Vortex" system it is found that when supercharged a higher swirl rate is required. Fortunately, the swirl produced increases in nearly the same ratio, so that no alteration in the swirl-producing arrangements is required. Again, with certain medium-swirl systems it has been found that a somewhat lower swirl ratio is required at part loads than at full load.

Compression Swirl Production and Utilisation.—The design of most compression swirl engines is such that the fitting of a swirl meter is difficult for mechanical reasons; as a result swirl measurements on this type are rare. As some compensation for this the theory is much simpler, since in normal engines the velocity through the throat is fairly low, and elasticity effects are therefore small. The statement that the throat velocity is low, may appear surprising, in view of the small area of the throat relative to that of the piston, but the explanation is that during most of the compression stroke a small part only of the air displaced by the piston enters the combustion chamber, the remainder being compressed above the piston.

Simple reasoning shows that in this type (if we ignore viscosity and elasticity effects) the swirl ratio is independent of engine speed and size, and is, other things being equal, inversely proportional to the throat area. Experimental confirmation is lacking, except over a very limited speed range, but the approximate independence of engine speed and size is suggested by the fact that engines of this type usually give a good performance over a wide speed range, and that the same throat proportions suit engines of widely different sizes.

The swirl ratios given by calculation are, as a rule, extremely high. In a typical Ricardo "Comet" engine, for example, the calculated swirl ratio is about 55. The actual value has not been measured, but in an engine of somewhat similar type of which the calculated swirl ratio was 42, the observed figures averaged about 14, or one-third of the calculated value, the difference being presumably due to friction. In the "Comet" type wall friction is not likely to be so great, and the actual swirl ratio is probably about 20 to 25.

Very little can be said as to the swirl requirements of the compression swirl type, owing in part to the dearth of experimental evidence, and in part to the fact that any change which affects the swirl affects also the conditions of outflow from the combustion chamber during the expansion stroke. All that the author can say is that in

FIG. 9.—*Secondary Air Circulation at end of compression stroke ("Vortex" combustion chamber).*

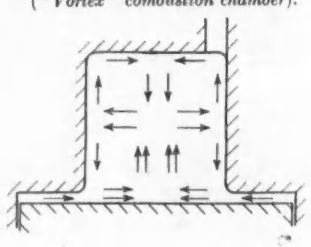
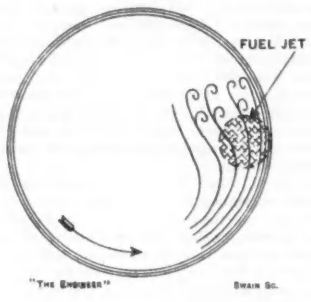


FIG. 10.—*Air Disturbance and Inward Flow due to obstruction of swirl by fuel jet.*



the "Comet" type the best all-round results for vehicle work appear to be given with the above-mentioned theoretical swirl ratio. Enlarging the throat area and thus reducing the swirl improves the output at high speeds at the expense of low-speed torque, while reducing the throat area has the opposite effect.

The Nature of Swirl and its Effect on the Fuel Spray.—There is evidence that the swirling charge does not rotate as a solid mass but rather as a free vortex, the speed of rotation increasing towards the axis. This is shown by the fact that in a "Vortex" combustion chamber the swirl meter rotates faster if the vane diameter is decreased.

A feature of nearly all swirl type engines is that the fuel is directed across the air flow, not necessarily at right angles, but with a large transverse component. The Perkins engine is the only exception to this rule (if we except air cell engines). The action of the air appears to be that of blowing the fine spray in the jet clear of the heavier particles and allowing the latter to receive their ration of fresh air.

It is clear that in the "Vortex" type—Fig. 7—the fuel would, if the air movement was one of pure rotation, reach only the circumferential layer of air; likewise, in the "Comet" type—Fig. 6—on the same assumption, the fuel would be confined to a narrow diametral slice. In both types, however, the percentage of air effectively utilised is 80–85 per cent., so one is forced to the conclusion that the air in the apparently inaccessible zones does, in fact, get its fuel ration. This, in turn, means that there must be superimposed on the swirl proper some other form of air motion. In the "Comet" type there is no evidence as to the nature of this motion, but in the "Vortex" system markings on the combustion chamber walls suggest that the fuel spray moves inwards, in a spiral path, whereas one would at first sight expect it to move outwards. For this effect there are several possible explanations, but as to the extent to which each factor enters into the final result one can only make the vaguest of guesses.

(1) The piston approaching the outer annulus of the cylinder head expels the trapped air, thus creating an inflow at the bottom of the combustion chamber.

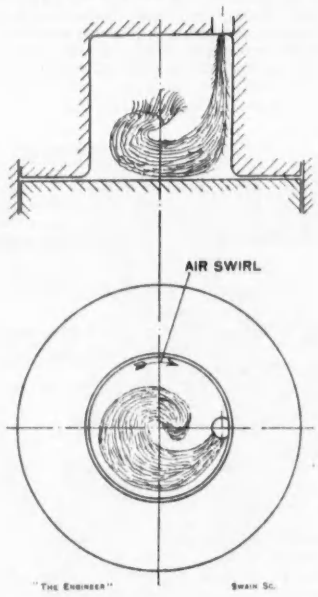
(2) The friction of the end walls reduces locally the rate of rotation, and therefore the centrifugal pressure gradient, below that obtaining at mid-height. This causes the air to move inwards at the ends and outwards in the middle. This effect can be demonstrated by stirring a cup of water with some tea-leaves in it, when the inflow at the bottom will cause the leaves to collect at the centre. The combined effect of these two factors should give the circulation shown in Fig. 9, the central outflow being displaced upwards by the "squish" inflow at the bottom end.

(3) Another factor is the obstruction due to the fuel jet, which at first has no tangential velocity. Looking at Fig. 10, one sees that the air must make a detour round the jet, and since the latter is very near the side wall, most of the air must move inwards.

(4) The flame from the jet, being hotter and therefore lighter than the unburnt air, tends to be moved by centrifugal force inwards, displacing fresh air to the outside.

Taking into account all these factors one may tentatively picture the jet path as being that shown in Fig. 11. It first travels more or less straight down the side, the fine spray being blown inwards at the top and outwards at the middle, as shown. Before reaching the lower end it has lost most of its velocity, so is easily drawn inwards by the

FIG. 11.—*Probable Path of Fuel Jet ("Vortex" combustion chamber).*



bottom inflow, later following the air stream up the central core and outwards at the mid-height.

This picture is, of course, highly imaginative, but in the absence of direct evidence one has to make what use one can of circumstantial evidence.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

THE Council of the Society of Motor Manufacturers and Traders, Ltd., has appointed Mr. A. W. Grafton to be Assistant Secretary as from Thursday, December 13th, 1934.

GREENWOOD AND BATLEY, Ltd., Leeds, inform us that they have appointed Biram and Co., Ltd., as their representatives for the Eastern Counties with offices at Felixstowe and Norwich.

PALMERS GALVANIZING COMPANY, Jarrow-upon-Tyne, has taken over the galvanising department of the Palmers Shipbuilding and Iron Company, Ltd. The management will remain exactly as before.

MR. JOHN TURNER, A.M.I.E.E., has been appointed by the Government of the Punjab, Maintenance and Test Engineer in the Electricity Branch of the Punjab Public Works Department.

COLONEL C. F. HITCHINS, D.S.O., M.I. Mech E., M.I.N.A., of Messrs. Hitchins, Jervis and Partners, consulting engineers, Westminster, has joined the board of the Partington Steel and Iron Company, Ltd.

MR. J. M. ARMEL, manager of the Vacuum Oil Company's Birkenhead Works, has retired after twenty-eight years' service in that capacity. He is being succeeded by Mr. W. S. Church, who, for many years, has been his assistant manager.

MR. ALFRED MARSDEN, one of the Glasgow representatives of the Vacuum Oil Company, who completed forty-five years' service with the company last February, has retired. Mr. Marsden held the Vacuum Oil Company's long-service record.

THE SOCIETY OF MOTOR MANUFACTURERS AND TRADERS, Ltd., has decided to establish an office in India, and has appointed as its representative Mr. Dennis Edward Gough B.Sc. It is intended that the territory to be covered shall include Ceylon and Burma.

GEORGE ELLISON, Ltd., Birmingham, 20, inform us that their Birmingham and Midland sales and service office will, after December 25th, be situated at Lombard House, Great Charles-street, Birmingham, 3. Similar intimation has been received from Ellison Insulations, Ltd.

THE D.P. BATTERY COMPANY, Ltd., Bakewell, Derbyshire, informs us that its representative for the East Midland district, Mr. S. J. Suter, will be retiring, and that Mr. H. Ellithorne, who has been with the company for more than eight years, will take over the district on January 1st, 1935.

THE WORLD POWER CONFERENCE INTERNATIONAL EXECUTIVE COUNCIL AND BRITISH NATIONAL COMMITTEE has removed from 63, Lincoln's Inn-fields, W.C.2, to 36, Kingsway, W.C.2 (Fifth Floor). Telephone, Holborn 5561; telegrams, Worpowcon, Holb, London; cablegrams, Worpowcon, London.

THE STANTON IRONWORKS COMPANY, Ltd., near Nottingham, has taken up the production of high manganese pig iron, and has appointed as sole selling agents of this iron R. G. Stone and Co., Ltd., of London. The Stanton Company is proceeding to produce this iron at its Stanton Works, and at the works of the Wellingboro' Iron Company, Ltd., Wellingborough.

COCHRANES (MIDDLESBRO') FOUNDRY, Ltd., informs us that it proposes to extend its centrifugal pipe-making plant at Middlesbrough-on-Tees, which, during the past few years, has been engaged on making spun iron pipes under licence of the patented Mairy process. The new plant will embrace six further centrifugal machines, and will be operated under the same patented process.

Markets, Notes and News.

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer. A comprehensive list of the prices of materials mentioned below will be found on the next page.

Import and Export Statistics.

The chief feature of the Board of Trade returns of imports and exports of iron and steel for November is a noticeable decrease in the volume of imports and a small decline of just over 1000 tons in the exports. The imports for November totalled 104,086 tons, whilst in October they were 120,197 tons. The value of the October imports was £803,710 and in November it fell to £693,027. Although the exports of iron and steel declined from 220,927 tons in October, valued at £3,475,323, to 219,879 tons in November, the value increased to £3,504,095. For the eleven months ending November 30th the total imports were 1,252,399 tons, valued at £8,414,551, whilst the total exported reached 2,066,819 tons, valued at £32,122,014. In November 12,951 tons of pig iron were imported, of which 11,199 tons came from India, whilst of the remainder 1280 tons was iron smelted wholly with charcoal. In October 13,096 tons of pig iron were imported. There was a marked decline in the total of blooms, billets and slabs brought into the country, from 40,865 tons in October to 19,442 tons in November. The reduction occurred principally in Belgian imports, which dropped from 21,166 tons in October to 7765 tons last month. The imports from France showed a slight gain from 7460 tons in October to 8221 tons in November. On the other hand, there was a sharp increase in the imports of sheet bars, which rose from 6806 tons in October to 13,537 tons. In this case the Belgian imports showed an increase from 6295 tons to 12,531 tons in November. Another feature of the figures relating to the semi-finished section is the revival of the import trade in sheet bars, which in October totalled 1022 tons and rose in November to 3295 tons. The imports of general steel, such as bars, shapes, and sections, which amounted to 21,475 tons in October, dropped slightly to 20,720 tons in November. There was a decline also in the total of girders, beams, joists, and pillars from 8237 tons in October to 6874 tons last month. Belgium sent the largest quantity of steel, the total being 51,935 tons, France coming next with 13,464 tons, and then Luxemburg with 8523, whilst Germany exported to this country only 7324 tons.

Our Steady Export Trade.

Export figures relating to iron and steel show that the improvement noticeable a month ago was maintained during November. Pig iron was exported to the extent of 13,384 tons last month, compared with 12,269 tons in October. The exports of general descriptions of steel, which in October amounted to 18,933 tons, declined slightly to 18,033 tons in November. In the latter month India was the best customer with 3071 tons, South Africa coming next with 2980 tons and Australia third with 1317 tons. The exports of girders, beams, joists, and pillars also declined last month to 2487 tons, compared with 4221 tons in October, whilst the overseas trade in hoop and strip remained practically stationary, being 4435 tons in October and 4394 tons in November. The exports of plates and sheets not under ¼in. thick reached 13,052 tons in November, the figure for the previous month being 13,274 tons. Plates and sheets under ¼in. thick sent abroad last month amounted to 15,554 tons, against 15,887 tons in October. India, however, took 2547 tons, compared with 1592 tons in the previous month, and Japan 3798 tons, compared with 1780 tons in October. The overseas trade in galvanised sheets showed an improvement to 26,183 tons, compared with 22,941 tons in October, Indian exports increasing from 4453 tons to 5841 tons. The next best customer was Australia, which took 4851 tons. Exports of tin-plates also showed an improvement to 40,356 tons, against the October total of 36,365 tons. Overseas business in tubes fell from a total of 25,840 tons in October to 22,167 tons in November. There was also a small decline in the exports of railway material, which reached 15,487 tons in November, compared with 16,013 tons in the previous month. Details of the exports of this class of material show that 8731 tons of new steel rails were sent abroad in November, against 9277 in October, whilst the exports of sleepers and fish-plates reached 3478 tons in November, against 2177 tons in the previous month. The total of tyres and axles dropped to 1501 tons, compared with 1756 tons. South Africa was the best customer of this country in November, taking 23,546 tons, India being a close second with 23,024 tons, and Australia coming next with 21,641 tons. The exports to Canada reached 17,104 tons. Of the foreign countries, the Argentine took 10,764 tons, Denmark being next with 9173 tons, and Japan third with 8329 tons.

The Pig Iron Market.

Taking it all round, the market for pig iron has not been so much affected by seasonal conditions as is usual at the end of the year. New business is definitely on a smaller scale than of late, but, on the other hand, there is considerable pressure from consumers who wish to obtain delivery before the holidays. There is, of course, a certain amount of business passing in small parcels for near delivery, and a few consumers are negotiating for forward contracts extending over the first quarter of 1935. The North-East Coast makers are finishing the year in a good position, and are by no means anxious to enter into extended forward commitments. There is some talk of a price advance in this market, but consumers are inclined to think that the present level of prices will rule for a long time to come. Deliveries to the Scottish foundries keep up well and new business is under negotiation. The export demand remains disappointing, and the recent currency decrees in Italy have created nervousness amongst suppliers in this market. Export business, however, has shown a tendency to increase during the past week or two, and the price of foundry No. 3 may now be called 61s. 6d. f.o.b. The Midland pig iron market has developed a distinctly quiet tone, and it is not expected that business will revive to any appreciable extent until the middle of January. This is partly due to the decrease in the demand from the light castings foundries, which cater for the building trades. On the other hand, the heavy engineering concerns and the jobbing engineers are taking more iron than for several months past. It is certain now that the deliveries to consumers will not be so heavy in December as last month, and that undelivered balances of contracts will be carried forward into the New Year. It is possible, also, that during the month stocks have been slightly added to. In Scotland all three furnaces are in blast, and the foundry iron produced is meeting with a steady outlet. In Lancashire, also, although there has been some slackening in the demand from the light castings industry, the general tendency of the market has been satisfactory. Business in hematite has been fairly active considering the time of the year, and some good contracts have been placed by consumers in Sheffield and the Midlands.

British Iron and Steel Production.

The British Iron and Steel Federation, in its monthly statement for November, reports that the production of pig iron during that month amounted to 507,600 tons, compared with 527,100 tons in October and 374,900 tons in November, 1933. This included 131,400 tons of hematite, 248,000 tons of basic, 113,600 tons of foundry, and 8400 tons of forge pig iron. The output of steel ingots and castings shows a slight decline to 766,000 tons, against 812,000 tons in October and 695,000 tons in November last year. At the end of the month there were ninety-six furnaces in blast, a net decrease of one since October, two furnaces having been blown in and three having ceased operations. Particulars are not given in the report, but of the two furnaces blown in one was at the Earl of Dudley's Round Oak Works, Ltd., Brierley Hill, and the other at Lloyds Ironstone Company, Ltd., Birmingham. Of the three furnaces put out of commission one was at John Lysaght, Ltd., Bristol; one at the Goldendale Iron Company, Ltd., Tunstall, and one at G. and R. Thomas, Ltd., Bloxwich, Staffs. The following table gives the monthly average production of pig iron, steel ingots, and castings over a period of years, and the output for the past four months of the current year :—

	Pig iron. Tons.	Steel. Tons.
1913—Monthly average	855,000 ..	638,600
1920 „ „	669,500 ..	755,600
1929 „ „	632,400 ..	803,000
1931 „ „	314,400 ..	433,500
1932 „ „	297,800 ..	438,500
1933 „ „	343,600 ..	583,600
1934—August	503,300 ..	667,000
September	500,300 ..	734,700
October	527,100 ..	812,000
November	507,600 ..	766,000

The North-East Coast and Yorkshire.

The steel works on the North-East Coast are maintaining a good rate of operations, and can look forward to the New Year with more confidence than a few weeks ago. The requirements of the railway companies for next year are expected to be on a heavy scale, and it is reported that specifications for 1935 delivery are reaching the works much earlier than usual. More business is being received from the shipyards recently than for some months, and it is thought that the demand from this industry will increase in the course of the next few weeks. It is also expected that the steel industry will benefit from the subsidy to shipowners. The structural engineers on the North-East Coast have been well employed practically all the year and are still engaged upon good contracts. In fact, their requirements of joists and sections seem, if anything, to be increasing. Considerable interest is felt in this district as to the effect of the new agreement between the steel makers and the constructional engineers, as for some years the engineering firms connected with local steel-making concerns have taken a large share of the home contracts to the great advantage of the steel works. It remains to be seen if the same volume of business will come to this district in the future. The production of semi-finished steel has been maintained throughout the autumn, and the works have good order books with which to begin the New Year. Consignments of foreign semis continue to reach the re-rollers on this coast, but the home makers take most of the business. The satisfactory conditions which have ruled in the Yorkshire industry show little signs of deterioration in spite of seasonal influences. Many of the works in the Sheffield area are operating at capacity or very close to it, and it is stated that the Templeborough Works have ten furnaces in commission and are making a record output of 11,000 tons of basic steel per week. The mills engaged on railway material are fairly well employed but there has been some decline in activity at the tyre and axle works. The output of stainless steel keeps up well, and in this department new business shows little sign of falling off. The machine tool makers, however, although they have good order books, are not booking many fresh contracts.

Current Business.

The Blaenavon Blast Furnaces have been acquired for demolition by Thos. W. Ward, Ltd., Sheffield. One of the furnaces was reconditioned recently, and it was expected that pig iron production would be resumed. The directors of the Blaenavon concern, however, have decided not to maintain the blast-furnaces, but to concentrate upon colliery and steel activities. The plant consists of three blast-furnaces and ten hot blast "Cowper" stoves with turbo-blowers, Halberg gas-cleaning plant, and necessary equipment. These ironworks have existed for more than 150 years, and during that period several eminent ironmasters have been connected with them. Their demolition will sever a link in the chain of ironworks which formerly stood at the head of the Monmouth and Glamorgan valleys. A new steel bridge is to be built over the river Anker at Tamworth to replace the present structure. The cost will be about £17,000, and the bridge will have a 30ft. carriageway and two 6ft. paths. A contract for a 50,000 kW surface condenser plant with auxiliaries and closed-feed system has been awarded to Hick, Hargreaves and Co., Ltd., by the West Midland Joint Electricity Authority. Greenwood and Batley, Ltd., of Leeds, have secured an order for four "Greenbat" electric mining locomotives for export. An order has been placed by Coast Lines, Ltd., for a coastal ship of 1600 tons gross with Henry Robb, Ltd., Victoria Shipyard, Leith. Stewarts and Lloyds, Ltd., have received an order for 4000 tons of drawn steel boiler tubes for the Buenos Aires Railway. John Lysaght, Ltd., are to install a continuous strip mill for the rolling of high grade steel sheets. The Department of Overseas Trade announces that the following contracts are open for tender :—Argentine State Railways Administration : Copper rods and plates (Buenos Aires, January 3rd); Indian Stores Department : 40,000 rail anchors for 115 lb. rails (New Delhi, January 4th); Egypt, Ministry of the Interior: one mobile motor bacteriological laboratory (Egypt, January 14th), four small fire-engines (Egypt, January 3rd); Ministry of Communications : supply and erection of a portable aeroplane hangar at El Arish (Cairo, January 3rd); Royal State Railways, Siam : 2000 fish-plates, 25,500 fish-bolts and nuts, and 122,352 dog spikes (Bangkok, January 4th).

Copper and Tin.

The improvement in the copper market noted last week has lasted longer than some people expected, and although prices have advanced to only a moderate extent, a more confident tone prevails than for a long time. The better feeling is entirely due to the belief which now seems general that a scheme for regulating output all over the world will be adopted at a meeting of the copper producers in January. It is reported that the scheme provides either for a reduction of 20 per cent. all round upon the rate of production ruling this year, or that the output shall be continued at the level of 1934. The market is inclined to favour the latter proposal, as it is thought that the first alternative will be of such a drastic character that it might check consumption, which is beginning to improve by occasioning a violent upward price movement. The recent Italian currency decrees have rather disturbed the market, as Italy has been a buyer of rough copper for sulphate making. Italian buyers have always met their engagements, although the difficulties of exchange have at times caused a delay; but the experience of sellers in the case of some other countries has naturally made them rather anxious regarding the effect of the latest Italian regulations. The London standard copper market has shared in the general improvement. Speculators have not been so active of late, and seem to be holding as much copper as they require. At the moment, there is a good-sized bull account outstanding. . . . Featureless conditions have ruled in the tin market. The demand is steady, but has naturally been affected by the approaching holidays. British consumers have taken good quantities, but the demand from the United States has again declined and little business has been transacted with the Continent. Interest is being taken by the market in the expansion which is taking place in the Belgian Congo mining district. One of the most important companies has stated that its output will be increased. It is also announced that smelting operations have been commenced in the Congo, and that ore will be treated there which was formerly sent to Belgium.

Lead and Spelter.

The lead market has been affected, like most other departments of commerce, by the approach of the holidays. Consumers in this country have limited their purchases, whilst abroad the trade demand, which has not been good for some time, has further declined. The arrivals of Mexican lead had the effect of slightly weakening the market, but some of the metal was taken up by consumers, who paid the duty and took the metal into their works. This, of course, was due to the scarcity of Empire brands and the high premiums required for duty-free metal. Considerable resentment is expressed by the consuming trades in this country at the difficulty of obtaining Empire metal, and representations have been made that the duty upon foreign lead should be removed, or at least withdrawn, until such time as the Empire producers can supply the requirements of the market. Probably, if Empire lead were needed promptly a premium of 25s. would be demanded. . . . Prices in the spelter market have fluctuated within narrow limits, but the trade demand for the metal has not been good. Some improvement is reported from the Continent, but in this country the demand is not more than moderate. Nothing definite is known as to the fate of the International Zinc Cartel, but it is generally assumed that it will be dissolved at the end of the year unless some last-minute method of overcoming its difficulties is devised. According to figures published by the Cartel there was a decrease in the stocks in November to 1250 tons. Japan has been in the market for zinc and has placed an important order with the Polish producers. In the United States it is suggested that a reduction of 15 to 20 per cent. should be made by the American producers.

Current Prices for Metals and Fuels.

Makers' official home trade prices, per ton, delivered buyers' stations. Sections, joists and plates are subject to a rebate to home users purchasing only from associated British Steelmakers: joists, 22s. 6d.: plates and sections, 15s. Export orders of 250 tons and over may be subject to special quotations.

PIG IRON.

	Home.	Export.
	(*D/d Teesside Area*)	
N.E. COAST—	£ s. d.	£ s. d.
Hematite Mixed Nos.	3 8 6	3 2 0
No. 1	3 9 0	3 2 6
Cleveland—	(*D/d Teesside Area*)	
No. 1	3 10 0	3 4 0
No. 3 G.M.B.	3 7 6	3 1 6
No. 4 Forge	3 6 6	3 0 6
Basic (*Less 5/– rebate*)	3 7 6	—
MIDLANDS—		
Staffs.—	(*Delivered to Black Country Station*)	
North Staffs. Foundry	3 11 0	—
„ „ Forge	3 6 6	—
Basic (*Less 5/– rebate*)	3 12 6	—
Northampton—		
Foundry No. 3	3 7 6	—
Forge	3 2 6	—
Derbyshire—		
No. 3 Foundry	3 11 0	—
Forge	3 6 0	—
SCOTLAND—		
Hematite, f.o.t. furnaces	3 11 0	—
No. 1 Foundry, ditto	3 12 6	—
No. 3 Foundry, ditto	3 10 0	—
Basic, d/d (*Less 5/– rebate*)	3 7 6	—
N.W. COAST—		
Hematite Mixed Nos.	3 12 6 d/d Glasgow 4 0 6 „ Sheffield 4 5 6 „ Birmingham	

MANUFACTURED IRON.

LANCS.—	Home. £ s. d.	Export. £ s. d.
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
S. YORKS.—		
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
MIDLANDS—		
Crown Bars	9 15 0	—
Marked Bars (Staffs.)	12 0 0	—
Nut and Bolt Bars	7 5 0 to 7 15 0	—
SCOTLAND—		
Crown Bars	9 12 6	9 5 0
Best	10 2 6	9 15 0
N.E. COAST—		
Common Bars	9 12 6	8 15 0
Best Bars	10 2 6	9 15 0
Double Best Bars	10 12 6	10 0 0

STEEL.

LONDON AND THE SOUTH—	Home. £ s. d.	Export. £ s. d.
Angles	8 10 0	7 7 6
Tees	9 10 0	8 7 6
Joists	8 17 6	7 7 6
Channels	8 15 0	7 12 6
Rounds, 3in. and up	9 10 0	8 7 6
„ under 3in.	8 14 6	—
Flats, 5in. and under	8 14 6	7 2 6
Plates, ¼in. (basis)	9 0 0	7 15 0
„ 5/16in.	9 5 0	8 0 0
„ ⅜in.	9 10 0	8 5 0
„ 7/16in.	9 15 0	8 10 0
„ ½in.	9 10 0	8 5 0
NORTH-EAST COAST—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Plates, ¼in.	8 15 0	7 15 0
„ 5/16in.	9 0 0	8 0 0
„ ⅜in.	9 5 0	8 5 0
„ 7/16in.	9 10 0	8 10 0
„ ½in.	9 5 0	8 5 0
Boiler Plates, ¼in.	9 5 0	8 5 0
MIDLANDS, AND LEEDS AND DISTRICT—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¼in. (basis)	8 17 6	7 15 0
„ 5/16in.	9 2 6	8 0 0
„ ⅜in.	9 7 6	8 5 0
„ 7/16in.	9 12 6	8 10 0
„ ½in.	9 5 0	8 5 0
Boiler Plates, ¼in.	9 7 6 . 7 15 0 to 8 5 0	

STEEL (*continued*).

GLASGOW AND DISTRICT—	Home. £ s. d.	Export. £ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¼in. (basis)	8 15 0	7 15 0
„ 5/16in.	9 0 0	8 0 0
„ ⅜in.	9 5 0	8 5 0
„ 7/16in.	9 10 0	8 10 0
„ ½in.	9 5 0	8 5 0
Boiler Plates	9 5 0	8 5 0
SOUTH WALES AREA—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 0
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¼in. (basis)	8 17 6	7 15 0
„ 5/16in.	9 2 6	8 0 0
„ ⅜in.	9 7 6	8 5 0
„ 7/16in.	9 12 6	8 10 0
„ ½in.	9 10 0	8 5 0

IRELAND—	BELFAST. £ s. d.	REST OF IRELAND. £ s. d.
Angles	8 12 6	8 15 0
Tees	9 12 6	9 15 0
Joists	9 0 0	9 2 6
Channels	8 17 6	9 0 0
Rounds, 3in. and up	9 12 6	9 15 0
„ under 3in.	9 2 0	9 4 6
Plates, ¼in. (basis)	9 0 0	9 2 6
„ 5/16in.	9 5 0	9 7 6
„ ⅜in.	9 10 0	9 12 6
„ 7/16in.	9 15 0	9 17 6
„ ½in.	9 12 6	9 15 0

OTHER STEEL MATERIALS.

Sheets.	Home. £ s. d.	Export. £ s. d.
10-G. to 13-G., f.o.r.	9 0 0	8 15 0
14-G. to 20-G., d/d	10 5 0	9 0 0
21-G. to 24-G., d/d	10 10 0	9 5 0
25-G. to 27-G., d/d	11 2 6	9 17 6

The above home trade prices are for 4-ton lots and over; 2-ton to 4-ton lots, 10s. per ton extra; and under 2-ton lots, 30s. per ton extra.

Galvanised Corrugated Sheets, Basis 24-G.

Home.	£ s. d.
4-ton lots and up	13 0 0
2-ton to 4-ton lots	13 7 6
Under 2 tons	15 0 0

Export: £16 12s. 6d., c.i.f. duty paid India.
„ £11 5s. 0d., f.o.b. other markets.
„ Scandinavian Markets free.

Tin-plates.
20 by 14 basis, f.o.b. Bristol Channel ports, 18/2.
Tin-plate Bars, d/d South Wales Works, £5 7s. 6d.

Billets.	£ s. d.
Basic (0·33% to 0·41% C.)	6 12 6
„ Medium (0·42% to 0·60% C.)	7 2 6
„ Hard (0·61% to 0·85% C.)	7 12 6
„ „ (0·86% to 0·99% C.)	8 2 6
„ „ (1% C. and up)	8 12 6
Soft (up to 0·25% C.), 500 tons and up	5 10 0
100 tons	5 15 0
Rails, Heavy, 500-ton lots, f.o.t.	8 10 0
„ Light, f.o.t.	7 10 0

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	3/3 per lb.	
Ferro Tungsten	3/– per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£23 0 0	7/–
„ „ 6 p.c. to 8 p.c.	£21 12 6	7/–
„ „ 8 p.c. to 10 p.c.	£21 12 6	7/–
„ „ Specially Refined		
„ „ Max. 2 p.c. carbon	£34 0 0	11/–
„ „ „ 1 p.c. carbon	£38 15 0	12/–
„ „ „ 0·70 p.c. carbon	£42 0 0	12/6
„ „ „ carbon free	10d. per lb.	
Metallic Chromium	2/5 per lb.	
Ferro Manganese (loose)	£10 5 0 home	
„ Silicon, 45 p.c. to 50 p.c.	£13 0 0 scale 5/– p.u.	
„ „ 75 p.c.	£18 7 6 scale 6/– p.u.	
„ Vanadium	12/8 per lb.	
„ Molybdenum	5/3 per lb.	
„ Titanium (carbon free)	9d. per lb.	
Nickel (per ton)	£200 to £205	
Ferro Cobalt	5/3d. per lb.	

NON-FERROUS METALS.

Official Prices, December 19th.

COPPER—		
Cash	£28 1 3 to £28 2 6	
Three months	£28 10 0 to £28 11 3	
Electrolytic	£31 10 0 to £32 0 0	
Best Selected Ingots, d/d Birmingham	£32 0 0	
Sheets, Hot Rolled	£58 0 0	
	Home.	Export.
Tubes, Solid Drawn (basis)	9½d.	9½d.
„ Brazed (basis)	9½d.	9½d.
BRASS—		
Ingots, 70/30, d/d Birmingham	£27 0 0 to £29 0 0	
	Home.	Export.
Tubes, Solid Drawn, 2/1 Alloy	8½d.	8½d.
„ Brazed	10½d.	10½d.
TIN—		
Cash	£228 2 6 to £228 5 0	
Three months	£228 10 0 to £228 12 6	
LEAD	£10 5 0 to £10 10 0	
SPELTER	£11 12 6 to £11 18 9	
Aluminium Ingots (British)	£100	

FUELS.

SCOTLAND.

LANARKSHIRE—	Export.
(f.o.b. Grangemouth)—Navigation Unscreened	13/– to 13/6
„ Glasgow—Ell	16/–
„ „ Splint	17/–
AYRSHIRE—	
(f.o.b. Ports)—Steam	14/– to 14/6
FIFESHIRE—	
(f.o.b. Methil or Burntisland)—Prime Steam	14/–
Unscreened Navigation	12/6 to 13/6
LOTHIANS—	
(f.o.b. Leith)—Hartley Prime	12/6 to 13/9
Secondary Steam	13/–

ENGLAND.

YORKSHIRE, MANCHESTER—	
B.S.Y. Hard Steams	18/6 to 21/6
Furnace Coke	13/– to 17/6
NORTHUMBERLAND, NEWCASTLE—	
Blyth Best	14/6 to 15/–
„ Second	13/3
„ Best Small	10/6 to 11/–
Unscreened	12/6 to 13/6
DURHAM—	
Best Gas	14/6
Foundry Coke	18/6 to 22/6

SHEFFIELD	Inland.
Best Hand-picked Branch	24/– to 26/–
South Yorkshire Best	21/– to 23/–
South Yorkshire Seconds	17/6 to 19/–
Rough Slacks	8/– to 9/–
Nutty Slacks	7/– to 8/6

CARDIFF— SOUTH WALES.	
Steam Coals:	
Best Admiralty Large	19/6
Seconds	19/– to 19/4½
Best Dry Large	18/9 to 19/3
Ordinaries	18/3 to 18/6
Best Bunker Smalls	13/6 to 14/–
Cargo Smalls	11/6 to 12/6
Dry Nuts	22/– to 26/–
Foundry Coke	24/– to 37/6
Furnace Coke	19/– to 21/6
Patent Fuel	21/–
SWANSEA—	
Anthracite Coals:	
Best Large	37/6 to 40/–
Machine-made Cobbles	41/– to 51/–
Nuts	40/– to 50/–
Beans	25/– to 30/–
Peas	19/– to 22/6
Rubbly Culm	11/6 to 12/–
Steam Coals:	
Large	17/– to 20/6

FUEL OIL.

Inland consumption; contracts in bulk.
Exclusive of Government tax of 1d. per gallon.

Ex Ocean Installation.	Per Gallon.
Furnace Oil (0·950 gravity)	3½d.
Diesel Oil	4d.

Manchester prices ½d. per gallon extra.

French Engineering Notes.

(From our own Correspondent in Paris.)

Unemployment.

THE continuous increase in the returns of unemployment is not reassuring in view of the number of men who have already been absorbed by the preparations for putting in hand the programme of public relief works. It is now recognised that the programme will fail in its object unless it can be carried through in a much shorter period than the five years prescribed by the conditions governing the granting of the funds required. The Minister of Public Works declares that the undertakings now being started will only give employment to 70,000 men out of a total of 375,000. It is doubtful whether they can provide more employment in the iron, steel, and engineering trades which could easily deal with a moderate accession of business without taking on new hands. All the works are running short time. The decree to eliminate foreign workers is causing serious reactions abroad and trouble at home, and it has some repercussion, though perhaps indirectly, on the situation of French engineers in Spain, who may find themselves under the necessity of returning to their own country. There exists a convention whereby French workers are assimilated to the Spanish in respect of advantages accorded to them by national laws, and the French Government is urged to insist upon an observance of that convention. But there are similar arrangements between France and other countries which do not prevent foreign workers from being deprived of opportunities to find employment. The situation is unsatisfactory, and even at home employers complain of the inconvenience caused them by the refusal to renew permits for foreign workers.

South American Air Services.

The rivalry between the airship and the seaplane for transport between Europe and South America provides an interesting development of ocean air traffic. The service to Brazil was originally an extension of the African air lines created by Latécoère, of Toulouse, and was transferred to a new company, the Aéropostale, with a monopoly of the Brazilian air mail on condition that the mails should be carried by seaplane between Dakar and Natal, in Brazil, instead of by naval craft which the French Marine had placed at the disposal of the company. Aéropostale went into liquidation without having fulfilled the conditions of the Brazilian contract. Big seaplanes had been built, but they failed to give satisfaction. Meanwhile, the German airship was making successful journeys, and negotiations were undertaken to pool French and German interests on that line. Those negotiations fell through on the creation of "Air France," when the French Air Ministry made a further determined effort to preserve a monopoly of the service by means of seaplanes. The performances of the "Arc-en-Ciel" and the "Croix-du-Sud" aeroplanes were promising, and the good results were confirmed by the recent voyages of the Bleriot seaplane "Santos-Dumont." The seaplane must, however, be able to carry paying loads, and Latécoère is now completing a machine with a fuselage containing two decks to accommodate seventy passengers. The machine will be 164ft. across the wings and 105ft. in length. The engines will develop more than 5000 h.p., and the weight of the seaplane will be 37 tons. In designing these big machines French builders have learned something from failures in the past. All that can be said at present is that progress has been made in the construction of ocean seaplanes, and that the rivalry with the airship has entered upon a new phase. While, however, the commercial ocean seaplane is still in its early trial stage, the airship continues its regular journeys to schedule times.

Oil Locomotives.

The railway companies are experimenting with all kinds of locomotive and railcar types with a view to selecting the most suitable systems for new traffic conditions. While the P.L.M. Company has prepared plans for a powerful steam locomotive for accelerating the service between Paris and the South of France, it also proposes to run, in 1936, an oil locomotive with three Pullman cars and a van, which is expected to cover the distance between Paris and Nice in ten hours. Last year the company ran experimentally between Paris and Marseilles an oil-electric locomotive which had been built for its railways in Algeria, and owing to the trouble with bad water for steam boilers in that country, it is proposed to equip the whole of the Algerian system with oil locomotives. The experiment is, moreover, preparatory to the general use of oil locomotives throughout the African colonies. The locomotive being designed for the Paris-Nice service will have two bogey frames with four axles each and the eight axles will be driven independently by engines developing a total of 2000 h.p.

Shipping.

The returns of shipping laid up in French ports showed a diminution of tonnage for several months as the result partly of a reorganisation of services and more especially of sales of ships to foreign buyers, and it was expected that the application of the shipping subsidy would have accelerated the decline of laid-up tonnage. So far as cargo ships are concerned, the latest returns show that there were only 145 ships out of service as compared with 162 on September 1st, with a total of 391,777 tons, as against 422,218 tons. On the other hand, the number of ships of all classes laid up was 282 and the aggregate tonnage of 586,126 represented an increase of 22,124 tons. This increase is attributed to the higher total of 29 passenger ships and liners with an aggregate of 174,262 tons. More than 30,000 tons of ships were sold abroad, and only 5000 tons of new ships were purchased. The subsidy does not appear to be doing all that was expected of it, because French traffic has been so far reduced by trade restrictions that tramps have to look for international coastal freights which are not always easy to obtain.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgement is not illustrated the Specification is without drawings.

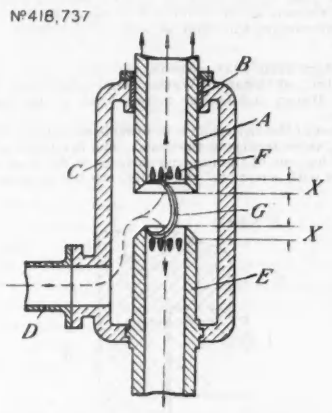
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgement, is the date of the acceptance of the complete Specification.

SWITCHGEAR.

418,737. August 29th, 1934.—ELECTRIC SWITCHES PROVIDED WITH ARC-QUENCHING MEANS, Siemens-Schuckertwerke Aktiengesellschaft, of Berlin-Siemensstadt, Germany.

The switch constructed in accordance with this invention comprises a hollow electrode A slidable in a guide B carried by a container C of insulating material for the quenching medium, the medium being supplied to the container through an inlet connection D. The electrode A is movable towards and away from a fixed second hollow electrode E carried by the container, and contacts with the electrode A when the switch is closed. Inside the hollow electrodes bars F are provided in closely spaced relationship with one another and of streamline form.

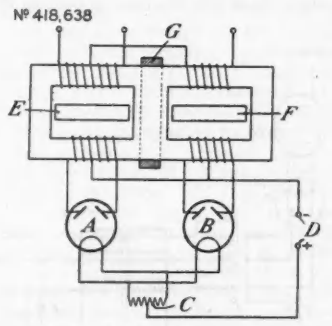


The arc drawn between the electrodes and indicated at G can only extend up to the grids formed by the bars, since it then attaches to the bars, which are conductively connected with the electrodes. The flow of the quenching medium is indicated by the arrows. The distance of the bars from the entrance to the respective electrodes indicated by X depends upon the potential and current which the switch is required to interrupt. Thus, for example, in the case of a heavy current and small potential, the distances X will be made comparatively small, whilst with a relatively small current and high potential the distances are larger. Any suitable compressed gas, such as air, or a mixture of gaseous and liquid mediums, can be used as the quenching medium.—*August 30th*, 1934.

TRANSFORMERS AND CONVERTERS.

418,638. April 27th, 1934.—ELECTRIC TRANSFORMERS, N. V. Philips' Gloeilampenfabrieken, of Emmasingel, Eindhoven, North-Brabant, The Netherlands.

This invention relates to polyphase leakage transformers for supplying welding rectifiers and the object is to improve the working of such rectifiers and to simplify the construction. The diagram shows a transformer, according to the invention, for converting three-phase current into a four-phase current. The primary windings are connected according to the Scott arrangement, so that the ratio of the turns of the primary windings should be $1 : \frac{1}{2}\sqrt{3}$. The secondary windings, which in order to increase the leakage are arranged on other parts of the iron core than the primary windings, are connected to the double-phase rectifiers A and B, which are preferably gas-filled incandescent cathode rectifiers. The cathodes are connected to the secondary winding C of a heating transformer.

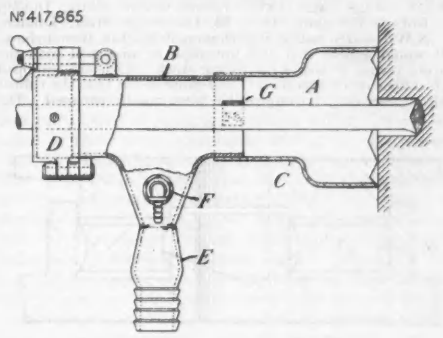


The load lies between the terminals D. E and F are iron bridge pieces which are preferably adjustable and serve for the direct-current control. The transformers consist of two single-phase transformers having a common yoke. This construction has the advantage that a saving in material is achieved, since the section of the common yoke may be smaller than that of two separated yokes. In order to avoid the mutual influencing of both parts, a short-circuited winding G, preferably a single winding consisting of good conducting material, for instance, copper, and having a large section, is provided. This winding is provided where the section of the leakage field is smallest, in order to ensure the greatest possible damping of the field with as little material as possible. During operation a current which may have a value of several thousands of ampères is set up in this winding owing to which the influence of the mutual leakage field is practically entirely avoided.—*October 29th*, 1934.

MINING MACHINERY.

417,865. April 12th, 1933.—DUST CATCHERS FOR ROCK DRILLS, Amalgamated Anthracite Collieries, Ltd., Eagle Chambers, Swansea, D. R. Davies and J. Davies, Ammanford Colliery, Ammanford, South Wales.

The drilling bit A is passed through a T-piece B, which is fitted with a rubber cap C bearing against the rock face. The edge of this cap, it will be seen, is serrated. At the other end of the T a more or less air-tight joint is made with the drill by means of hinged segments D. These segments may be changed to suit the size of drill in use. The side branch E of the T-piece

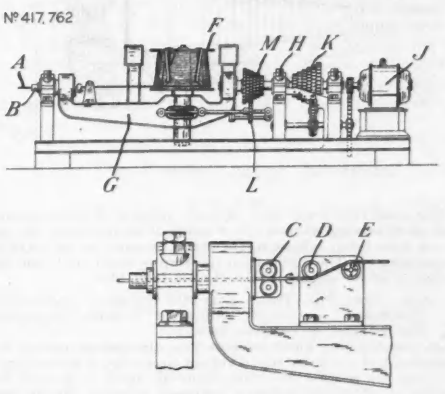


is of Venturi form, and is fitted with a compressed air jet F to induce a draught into a dust-catching bag, not shown. A bridge piece G carries the weight of the forward end of the T on the drill.—*October 12th*, 1934.

MACHINE TOOLS AND SHOP APPLIANCES.

417,762. March 12th, 1934.—TWISTING PROFILE WIRE FOR NAIL MAKING, G. L. Whist, Dronningensgate 22, Oslo, Norway.

It is pointed out that in twisting profile wire preparatory to its being made into helical, or "screw" nails, there is a liability for the pitch of the twist to become altered on account of varying hardness along the length of the coil of wire. The trouble is said to be overcome in this machine. The profile wire A is taken off a swift on the left (not shown), and is led through the stationary trunnion B and stationary guide rollers C, which prevent the wire rotating. It then passes over the guide rollers D and

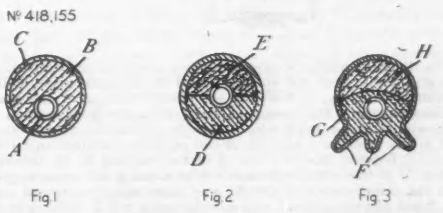


E to the winding block F. These rollers and the block are mounted on the yoke G, which is rotated on the trunnions B and H by the motor J and change speed gear K. The winding block F is rotated by the gear wheel L working round the fixed gears M. The wire is consequently twisted along the short length between the fixed and rotating guide rollers. The grooves of the rollers D and E have a smooth curved cross section which has the effect of exerting an increased torque on the wire when hard parts of the wire arrive between the rollers, as these hard parts of wire will be pressed more strongly against the rollers, owing to being bent partly about them than will be the case with the soft parts of wire.—*October 11th*, 1934.

LIGHTING AND HEATING.

418,155. May 19th, 1933.—ELECTRIC HEATING ELEMENTS, *International General Electric Company, Inc., of 120, Broadway, New York, U.S.A.*

Bar heating elements are known in which an electric resistance heating wire is embedded in insulating material wrapped in a metal sheathing with over-lapping edges. According to the invention, such a bar heating element in which the heating wire is encased in a seamless tube is so constructed that the heat given off by the element is greater on one side than the other, in that either the heat conduction of the resistance wire to the encasing tube or the radiation surface of the tube is not symmetrical as to the two sides. A number of forms of construction according to the invention are shown in the accompanying drawing. Fig. 1 shows a cross section through a bar heater element, which consists of the heating wire A, the insulating



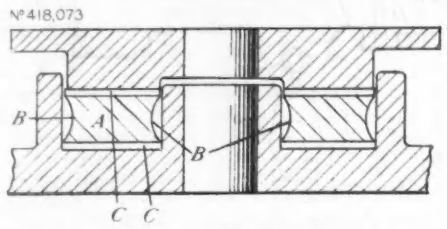
material B, and the sheathing or cover C. The heating wire A is arranged in such a way that it is located excentrically to the cover C. Between the lower side of the cover and the heating element A there is a layer of insulation of less thickness than between the upper side of the cover and the heating wire. By this means the heat radiated downwards will be the greater, since in this direction the heat encounters less resistance to its passage than it does in an upward direction. Fig. 2 shows a form of construction in which an excentric arrangement of the heating wire is not necessary. The desired result is obtained by employing insulating materials of different thermal conductivity. On the side the heat is to be radiated an insulating material D is provided having as great a thermal conductivity as possible, whilst at the other side an insulating material E, having as low a thermal conductivity as possible, is used. Furthermore, as shown in Fig. 3, the surface of the heating element may be artificially increased by ribs F, whereby the same effect is obtained. At the same time use may be made of the advan-

tages of employing different materials by providing a material G of good thermal conductivity on the ribbed side and a material H of poor thermal conductivity at the back.—*October 19th*, 1934.

MISCELLANEOUS.

418,073. June 14th, 1933.—RESILIENT BEARINGS, Dunlop Rubber Company, Ltd., 32, Osnaburgh-street, London, N.W.1, and S. Sadler, Fort Dunlop, Erdington, Birmingham.

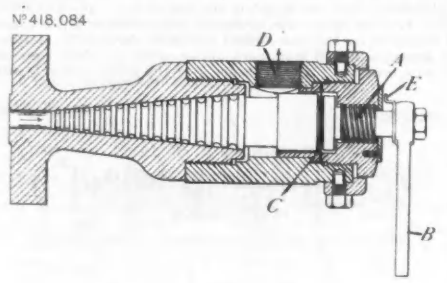
It would appear that this invention is concerned with the bearing pivots of bogies for rolling stock, which are equipped with rubber shock absorbers. It is pointed out that the rubber itself is practically incompressible when totally enclosed. The



inventors consequently form the rubber buffer A, with concave faces, as shown at B B, to permit the deformation of the rubber without it being pressed against the sides of the bearing with such a force that it will be damaged by heat produced by the relative movement of the two parts of the bearing. The rubber buffer is bonded to discs C C of metal or fibre.—*October 18th*, 1934.

418,084. October 7th, 1933.—STEAM TRAPS, Hopkinsons, Ltd., Wheathouse-road, Huddersfield, and R. L. Brown.

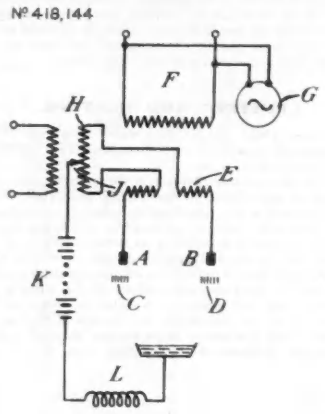
his steam trap is of the type in which a grooved conical plug acts in combination with a conical seating, the inlet being



at the small end of the cone. For the purpose of adjusting the cone in its seating, a screw A and handle B are provided, but are saved from being subject to the steam pressure by the flexible diaphragm C. The outlet from the trap is shown at D and an indicator of the setting at E.—*October 18th*, 1934.

418,144. April 21st, 1933.—ELECTRIC CURRENT CONVERTING DISCHARGE APPARATUS, Allmänna Svenska Elektriska Aktiebolaget, of Västeras, Sweden.

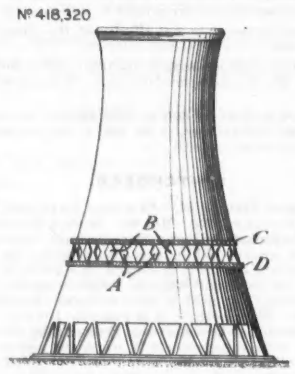
In transforming direct current into alternating current by means of grid controlled metal vapour apparatus, it is customary to effect the transfer of current from one anode to another by means of additional voltages impressed between the anodes. According to the invention, one or more additional transformers for introducing commutating voltages are connected between the anode coils of the main transformer and the neutral point of the anode side of the transformer. Not only is a better protection of these transformers thereby obtained, but the scheme also simplifies wiring, and, in the case of polyphase converters, all the additional transformers may be combined into one.



The diagram relates to a single-phase commutating apparatus. A and B represent the anodes, C and D the anode grids, E the primary winding, and F the secondary winding of the main transformer (for the passage of energy from the direct-current to the alternating-current side), and G the alternating-current load. H is the secondary winding of the additional transformer connected between the two halves of the winding E, the neutral point J of the additional transformer forming the negative pole of the direct-current network, and thus being connected over a direct-current source K and an inductance coil L to the cathode on the corresponding primary winding. The commutating voltage for raising the potential of one anode above that of the other is impressed on the primary winding of the additional transformer.—*October 19th*, 1934.

418,320. May 26th, 1933.—COOLING TOWERS, L. G. Mouchel and Partners, Ltd., of 36–38, Victoria-street, London, S.W.1; David William Lees, of 74, Northampton-road, Croydon, and Peter Joseph Gerard, of 55, The Chase, Norbury, London, S.W.16.

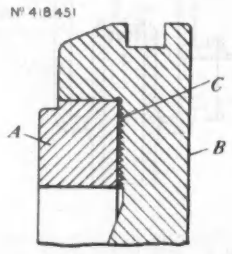
According to this invention additional cooling air is admitted to the inside of a cooling tower through apertures provided in the wall of the tower, the apertures being arranged so as to permit of substantially horizontal inflow. The tower is provided with a horizontal row of equidistantly spaced diamond-shaped apertures A capable of being exposed or partially or completely closed by means of similarly shaped shutters B. The shutters are interconnected to move in unison and run on rollers in upper and lower guides C, D, respectively. The shutters may be closed mechanically and may be arranged so that the opening and closing is automatically operated in conjunction with hygrometers and/or anemometers acting upon motors. Alternatively, the shutters may not be interconnected and may be closed individually by hand. Access to the apertures A and shutter



mechanism may be obtained by a steel ladder following the contour of the wall of the tower and giving access to a circular platform surrounding the tower adjacent the apertures.—*October 23rd*, 1934.

418,451. April 25th, 1933.—STEAM AND LIKE VALVES, Hopkinsons, Ltd., of Britannia Works, Huddersfield, and Richard Leslie Brown and George Sewell, both of the company's address.

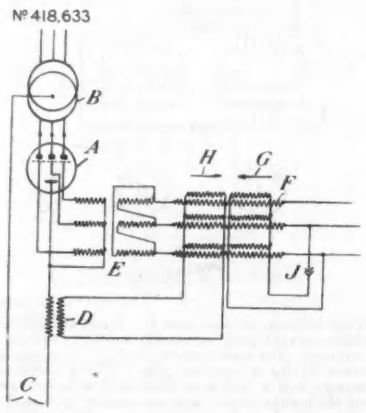
The object of this invention is to provide an improved method of securing valve facings in the seats. The invention is characterised in that one of the meeting surfaces of the seat or facing is provided with serrations which bite into the meeting surface



of the facing or seat. Conveniently the facing is reduced in temperature by means of a refrigerant, such as liquid air or liquid oxygen, before being passed into the seat. The illustration shows a facing ring A which has been contracted by immersion in liquid air, and then inserted into a seating disc B, the latter having serrations C in contact with the inner flat face of the facing. Several modifications of this arrangement are described.—*October 25th*, 1934.

418,633. April 4th, 1934.—ELECTRIC RECTIFIER INSTALLATIONS, The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C.2.

In accordance with this invention, a retardation in the increase of short-circuit current in rectifier installations is obtained by means of grid control, by supplying to the grid circuits a control alternating voltage variable in phase from a grid transformer having its primary winding in series with a choke provided with two saturating windings for changing the inductance thereof, one of the saturating windings being connected to a substantially constant source of direct current, while the other is influenced in accordance with the rate of increase in load current in such a way that the initiation of discharge is delayed with an increase in current. A multi-anode rectifier A is shown connected to a main transformer B, and a direct-current load circuit C. A choking coil is connected in the direct-current circuit and is provided with a secondary winding D. Grids in front of the anodes of the rectifier receive a controlling alternating voltage variable in phase through a grid transformer E under normal working conditions. A polyphase choke F is placed in series with the primary winding of the grid transformer. The change of phase position for the grid alternating voltage may take place by changing the induct-



ance of the choke F, namely, by adjusting the direct-current saturation. For this purpose, saturating windings G and H are provided, and actually the windings G receive a substantially constant direct current through an auxiliary rectifier J. The winding H is influenced by the rectifier current. In order to adjust the working conditions exactly, further impedances (not shown) are connected in series with or in parallel to the choke F and/or the primary winding of the grid transformer E. The winding H is connected to the winding D and a voltage is only induced in the winding H on changes of current in the main circuit. It should be noted further that the windings G and H of each limb are very closely coupled to one another, but each winding has a very small time constant in itself. If a short circuit is now set up on the direct-current side of the rectifier, the direct current will rise with a given velocity which is determined by the electrical data of the short-circuit. The rate of increase of the current is very great, particularly at the beginning. The current transformer D may be designed in such a way that at given rates of current rise, it induces given secondary voltages, and these voltages are led through the windings H of the choking coil F. In this way, the saturation effect of the winding G is removed, the inductance of the choking coil F is increased, and a phase displacement of the grid alternating voltage will be produced of such a nature that the initiation of any discharge current will be delayed.—*October 29th*, 1934.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

ELECTRO-DEPOSITORS' TECHNICAL SOC.—James Watt Memorial Inst., Birmingham. "Barrel Plating Technique," Mr. E. J. Dobbs. 7.30 p.m.

INST. OF BRITISH FOUNDRYMEN: JUNIOR SECTION.—College of Technology, Sackville-street, Manchester. "Cupola Practice," Mr. J. Jackson. 7.30 p.m.

JUNIOR INST. OF ENGINEERS.—39, Victoria-street, S.W.1. Lecture, "Regulations and Rules Affecting Luminous Discharge Tube Installations." 7.30 p.m.

PHYSICAL SOC.—At Northampton Polytechnic Inst., St. John-street, E.C.1. Inspection of Polytechnic Laboratories, 3 p.m.; meeting, 5 p.m.

SATURDAY, DEC. 22ND.

SHEFFIELD METALLURGICAL ASSOC.—198, West-street, Sheffield, 1. Young people's Christmas party. 3.30 p.m.

THURSDAY, DEC. 27TH.

ROYAL INST. OF GREAT BRITAIN.—21, Albemarle-street, W.1. Christmas Juvenile Lecture, I, "What is 'Electricity'?" Prof. W. L. Bragg. 3 p.m.

SATURDAY, DEC. 29TH.

ROYAL INST. OF GREAT BRITAIN.—21, Albemarle-street, W.1. Christmas Juvenile Lecture, II, "How Electricity Travels," Prof. W. L. Bragg. 3 p.m.

1935.

TUESDAY, JAN. 1ST, TO THURSDAY, JAN. 3RD.

PHYSICAL SOC.—Imperial College of Science and Technology, S.W.7. Annual Exhibition of Scientific Instruments and Apparatus. Tuesday, 3 p.m. to 6 p.m., 7 p.m. to 10 p.m.; Wednesday, 2 p.m. to 6 p.m., 7 to 10 p.m.; Thursday, 3 to 6 p.m., 7 to 10 p.m.

TUESDAY, JAN. 1ST.

ROYAL INST. OF GREAT BRITAIN.—21, Albemarle-street, W.1. Christmas Juvenile Lecture, III, "Motors and Dynamos," Prof. W. L. Bragg. 3 p.m.

THURSDAY, JAN. 3RD.

INST. OF LOCOMOTIVE ENGINEERS.—At Inst. of Mechanical Engineers, Storey's-gate, S.W.1. "A System of Limit Gauging Controlled by Colours with special Application to Locomotive Repairs," Mr. G. L. Murray. 6 p.m.

ROYAL INST. OF GREAT BRITAIN.—21, Albemarle-street, W.1. Christmas Juvenile Lecture, IV, "Our Electrical Supply," Prof. W. L. Bragg. 3 p.m.

FRIDAY, JAN. 4TH.

INST. OF SANITARY ENGINEERS.—Caxton Hall, S.W.1. Presidential address, Mr. W. E. Blizard. 6 p.m.

JUNIOR INST. OF ENGINEERS.—39, Victoria-street, S.W.1. Informal meeting. Lecture, "Notes on Fine Measurement," Mr. F. H. Rolt. 7.30 p.m.

SATURDAY, JAN. 5TH.

ROYAL INST. OF GREAT BRITAIN.—21, Albemarle-street, W.1. Christmas Juvenile Lecture, V, "Telegraphs and Telephones," Prof. W. L. Bragg. 3 p.m.

MONDAY, JAN. 7TH.

ROYAL AERONAUTICAL SOC.—At Inst. of Electrical Engineers, Savoy-place, W.C.2. "Imperial Air Routes," Mr. F. S. Gamble. 6.30 p.m.

CONTRACTS AND ORDERS.

The Editor is always happy to print short announcements of contracts and orders in this column provided they are sent to him in time to have news value and that they are likely to interest readers.

CRAVEN BROTHERS (MANCHESTER), Ltd., of Reddish, near Stockport, have recently secured the contracts for two very large lathes for important clients in Italy. One machine weighs approximately 330 tons and the other 250 tons, and they have to be completed for delivery to Italy in twelve months.

THE HOUSE OF LISTER.—Close upon 500 agents and friends sat down with members of the staff and directors of R. A. Lister and Co., Ltd., of Dursley, at the annual dinner and entertainment given by the firm, which, this year, took place on Wednesday, December 12th, at the Café Royal. The chair was taken by Mr. C. Percy Lister, the new chairman of the company, and the principal guest of the evening was Mr. Walter Elliot, the Minister of Agriculture, who proposed the toast of "British Industry." Mr. Elliot said that in the past too much harm had been done by regarding agriculture and industry as two separate things. They must always work together for the prosperity of the country. To-day, he said, the country was not unprosperous, and it must always be remembered that we were supporting a larger population on a higher standard of living than ever before. He looked upon British industry as a great agency for improving the social condition of the people. In his reply, Mr. Percy Lister referred to his recent world tour, during which, he said, he had done tangible business and laid the foundations for business still to come. Overseas trade was something, he said, which we must cherish and develop. With regard to Dursley, the year had seen more extensions than ever before, and an increase in the number of employees, with a record financial year. The toast of "The House of Lister" was happily proposed by Lieut.-Colonel Harold Fletcher. During the evening selections were given by the Lister Military Band, and each guest was presented with a souvenir napkin ring turned from the teak timbers of H.M.S. "Birmingham." After dinner the guests left the Café Royal in private coaches and proceeded to the Strand Theatre, where Mr. Leslie Henson's inimitable humour in the musical comedy "Lucky Break" was greatly enjoyed.

A Seven-Day Journal

Electricity Supply in Rural Areas.

A MEETING of the Conference on Electricity Supply in Rural Areas was held on Monday, December 17th, at the offices of the Electricity Commission, 2, Savoy-court, Strand, W.C.2. It was attended by representatives of the Incorporated Association of Electric Power Companies, the Association of Consulting Engineers, the Institution of Electrical Engineers, the British Electrical Development Association, the Electrical Association for Women, the Rural Industries Bureau, the National Farmers' Union, the Land Agents' Society, the British Electrical and Allied Manufacturers' Association, the Central Electricity Board, the Government Departments concerned, and other persons interested in the various aspects of rural electrification. Reference was made to the action taken by the Electricity Commissioners, authorised electricity undertakers, and others, since the date of the last meeting of the conference with a view to stimulating the development of the supply of electricity in rural areas. Among other matters discussed were certain difficulties experienced by potential consumers of electricity, and particularly farmers, in connection with the tariffs at present offered and charges made by authorised undertakers for supplies of electricity in rural areas. The Conference agreed that a small committee of its members should be appointed to consider the question of the most appropriate form of tariff or tariffs for supplies, including isolated supplies, in rural areas. Another matter discussed was the necessity for closer association between the National Farmers' Union and the supply undertakers. It was felt that the appointment of the proposed committee would be a useful step in the direction of closer working together.

Weak Bridges.

SPEAKING in the House of Commons on Thursday, December 20th, in answer to a question, the Minister of Transport said that, with the concurrence of the Chancellor of the Exchequer, an additional provision of £500,000 would be made available out of the Road Fund for grants to schemes for the reconstruction of weak bridges and for other urgent improvements with which highway authorities were ready to proceed immediately. He said that he was at once issuing grants at the rate of 75 per cent. towards twenty-five bridge schemes which, in all, were estimated to cost about £400,000; these were in addition to about eighty schemes for reconstructing weak bridges or replacing level crossings at a total cost of nearly £670,000 which had already been approved during the year. The consideration of further schemes of a like nature was already well advanced. The following are among the more important reconstruction and rebuilding schemes included in the £500,000 grant above mentioned:—The Tinsley Bridge at Sheffield, the Salt Hill railway bridge in Buckinghamshire, the Saxilby level crossing and old swing bridge, the New Barnet Station Bridge, five new bridges over the Leeds and Liverpool Canal in Lancashire, the Morden Halt and Mitcham Station bridges in Surrey, one bridge over the Forth and Clyde Canal at Hungryside, and two railway bridges at Shettleston and Addingstom in Lanarkshire, and the Sherburn Colliery bridge in Durham. Lesser schemes include a railway bridge at Percy-road, Twickenham; two new bridges in the West Riding of Yorkshire; a canal bridge at Oldbury, in Worcestershire; railway bridges at Birchfield road, Birmingham, and the Blackhole Colliery, in Derbyshire; the reconstruction of the three arches bridge at Shenfield, in Essex; a canal bridge over the Union Canal, Edinburgh, and one over the Birmingham Canal at Tipton, and the Glen Paroa Station Bridge, in Leicestershire. The Minister said that he was not altogether satisfied with the progress made, and that he had now arranged that action would be taken to ensure that the highway authorities which had responded to his appeal, including the schemes above referred to, would be able to proceed with their schemes without delay.

Sulphur Fumes and Battersea.

THE Government Chemist's Committee on Battersea Station has reported on the installation and performance of the plant erected by the London Power Company at Battersea for the purpose of eliminating sulphur fumes from the products of combustion of coal used for raising steam at the station, which, with some variations in the nature of the final alkaline washing, has been working for over six months. It reports that the amount of sulphur discharged as a sulphurous anhydride is now about 0·03 grain per cubic foot. The Committee is of the opinion that the London Power Company adopted "the best known means of preventing as far as reasonably practicable the evolution of oxides of sulphur." It is understood, it says, that a request may be made for the installation of three boilers to complete the immediate requirement of the London Power Company, and it would raise no objection to that proposal, subject to the same conditions of working as apply to the existing boilers which are giving at the present time the above-mentioned figure of 0·03 grain of sulphur per cubic foot. Whilst the Committee is impressed with the energy exhibited and success obtained by the London Power Company in treating the enormous volume of gases (such as 20 million cubic feet per hour from one chimney), and considers that performance a notable and pioneering achievement in chemical engineering, it recommends that before the completion of the station be sanctioned it would be well to have regard to developments in technical knowledge on the subject of the removal of sulphur gases from flue gases that may in the meantime have evolved. The results achieved from the present working of the plant for eliminating sulphur fumes, smoke, grit, &c., have fulfilled the expectations which were formed of the process during the experimental stage, and it is only because the problem is a new one and further improvement in the processes may reasonably be anticipated, that the Committee has recommended that sanction for the completion of the station should not be given without regard to the most recent developments in technical knowledge on the subject of the removal of sulphur compounds from flue gases. The Committee feels that on account of the thorough washing which the gases undergo, there is no cause to fear the deposition of solid matter from the chimneys. Visually, the white cloud of steam wihch issues soon dissipates, leaving nothing but a faint greyness, or not even that, and attempts to determine the solid matter in the washed chimney gases have so far failed to give any measurable quantity. Dr. J. F. Beale, who surveys the river for the Port of London Authority, states that there is no appreciable increase in the suspended matter, that the deoxygenating matter added is well within the statutory limit, and that the water has not been rendered acid.

The Don Drainage Scheme.

AT a meeting of the River Ouse (Yorkshire) Catchment Board, which was held at Leeds on Wednesday, December 19th, it was learned that the Minister of Agriculture, Mr. Walter Elliot, had refused to give a grant of more than 20 per cent. of the cost of the proposed £500,000 scheme for improvements to the river Don drainage. At its last meeting the Board, after considering alternative resolutions, resolved to inform the Minister that no further steps would be taken to carry out the proposed scheme, pending an offer of assistance which should meet with the approval of the Board. A deputation was accordingly formed to wait upon the Minister, and was introduced by Sir Eugene Ramsden. The deputation contended that the safeguarding of the banks of the Don against further flooding in the Doncaster area was a national rather than a local responsibility. Mr. Elliot received the deputation sympathetically, and fully discussed various aspects of the scheme proposed. He made it clear, however, that he could not see his way to recommend a grant of more than 20 per cent.

Low-Temperature Carbonisation.

AN interesting event in the progress of home-produced petrol and smokeless fuel took place on Wednesday, December 19th, when Mr. Ernest Brown, the Secretary of Mines, officially inaugurated a further extension of the Askern plant of Low-Temperature Carbonisation, Ltd. The total capacity of this plant has now been raised to 3200 tons of coal per week. The Minister was accompanied by an influential and representative company of chemists, engineers, and coalowners, representing the Mines Department, the Department of Scientific and Industrial Research, and fuel oil and coal interests. Mr. Brown performed the opening ceremony by releasing coal from the travelling skip to charge a pair of retorts. The visitors were conducted over the plant by Colonel W. A. Bristow, the chairman and managing director of the company, and his technical staff, and a very instructive account of the works and the process was given. In a short address, Mr. Ernest Brown referred to the importance of home-produced fuel, and said that as Secretary of Mines he watched with interest the successful efforts of Colonel Bristow and his fellow-directors to develop their own particular process and the series of undertakings that flowed from it, and he wished the new undertaking great success.

Engineering Wages.

ON Wednesday, December 19th, at the Great Central Hotel, Marylebone, a special conference took place between the Engineering and Allied Employers' Federation and the various trade unions, under the chairmanship of Sir John Siddeley. Mr. J. C. Little, of the Amalgamated Engineering Union, presented the case for the unions for an advance of 2d. per hour, with an equivalent advance to piece-workers, and a revision of the 1931 agreement. The ground of the unions' application may be briefly summarised as follows:—Skilled engineering workers are receiving very low wages in comparison with workers of comparable grades in many other industries and even in Trade Board trades. The engineering industry as a whole is now in a much better position than it was several years ago, and certain sections in particular are definitely prosperous. Moreover, the prospects are bright, and, in the unions' view, it is time the workers shared in this increasing prosperity. Not only have engineering workers suffered a debasement of their wage standards during the depression, but they have been severely hit by unemployment. Now that trade is improving it is only right that the workers' standards of living should be raised as partial compensation. No improvement in trade will be permanent unless mass purchasing power increases. Already certain other industries are increasing wages, and the resulting increase in purchasing power will lead to further prosperity for the constructional trades, including engineering. Engineering in turn must provide its quota to the general improvement of purchasing power by raising the wages of its workers. The unions pointed out that when dealing with the problem of wages, employers have constantly made the mistake of considering wage *rates* instead of wage *costs*, when dealing with costs of production. A decrease in wage costs is one means whereby selling prices can be reduced and the market expanded, but this is quite a different thing from a decrease in wage rates. Wage costs can be, and, in fact, have been, reduced without any fall in wages. A reduction in wage costs may be accompanied by an increase in wages, and this is obviously the most desirable thing for everybody concerned. A fall in wage costs without any fall in wages maintains consumers' purchasing power, and enables the market for engineering products to be expanded. Any fall in wages themselves, on the other hand, can only decrease the purchasing power of consumers, with the result that markets must be contracted instead of expanded. There will, therefore, be no increase in the sale of engineering goods if wages, and therefore consumers' purchasing power, are kept down.

A Tin Consumption Analysis.

STATISTICS issued by The Hague Statistical Office in the December *Bulletin* of the International Tin Research and Development Council show an increase of 4100 tons in the consumption of tin in manufacture for the year ended October, 1934, as compared with the previous year. World consumption in manufacture for the year ended October, 1934, is given as 132,900 tons, the figure for the previous year being 128,800 tons. The world's "apparent" consumption of tin for the twelve months ending October, 1934, is recorded as 115,000 tons, against 125,100 tons in the previous twelve months. Increases shown include Great Britain, 7·4 per cent.; Canada, 40 per cent.; Russia, 18·3 per cent.; The Netherlands, 67 per cent.; Belgo-Luxembourg, 38·4 per cent.; Sweden, 20·3 per cent.; Denmark, 20 per cent.; Japan, 19·2 per cent.; Poland, 15·8 per cent. Increases are recorded also for Italy, Spain, India, Norway, and Switzerland; whilst decreases include America, 26·2 per cent.; France, 5·8 per cent.; Germany, 2·5 per cent.; and Czechoslovakia, 9·3 per cent. The current trend of world consumption is downward, mainly on account of the seasonal decline in the United States, but also partly due to the falling tendency of consumption in France and Germany and some other countries. At the end of November the world's visible stocks of tin amounted to 18,598 tons, or 16 per cent. of the current annual rate of consumption. A comparison of the statistics of actual and "apparent" consumption indicates that during October invisible stocks decreased by about 2000 tons.

Institution of Naval Architects.

IN a Journal note of November 9th we referred to the impending retirement of Mr. R. W. Dana, the secretary of the Institution of Naval Architects, and the decision of the Council to appoint an assistant secretary, with a view to a full secretarial appointment. On Wednesday, December 19th, a well-attended meeting of the Council took place at the home of the Institution, Adam-street, Adelphi-terrace, when out of more than one hundred candidates the Council selected Lieut.-Commander Edgar P. Young, R.N. (Ret.), A.M.I.E.E., for the post of assistant to the secretary. Lieut.-Commander Young entered the Navy from Tonbridge School in 1917, and in the course of his training took the Naval Course at the University of Cambridge. He specialised in wireless and signals in 1925, and has since held the appointment of Fleet Signal and Wireless Officer on the staff of the Commander-in-Chief, China Station. He was later appointed officer in charge of H.M. Naval Wireless Station at Singapore, and supervised the erection of the new station. Lieut.-Commander Young qualified as interpreter in French and Russian, and has compiled a dictionary of technical terms in the Russian language. His knowledge of these and other European languages will enable him to further the international work of the Institution.

The Steel Ball: Early Methods of Manufacture.

By C. WATTS.

UNTIL the coming of the ball bearing steel balls were but little used. A few were made occasionally for testing and scientific purposes, and amateur mechanics turned them up now and again for their special work.

Steel ball production to-day is a large and important side of engineering. Made literally by the million, and to a very high degree of accuracy and finish, the hard steel ball is one of the most perfect of all manufactured articles, and a fine example of what specialisation and mass production can do.

At the present day it is interesting and well worth while to turn back the pages of engineering history and consider the many difficulties the pioneer ball makers had to contend with.

The early demand for the steel ball came from the makers of pedal-propelled vehicles for common roads. They were experiencing bearing troubles, owing mainly to the whip and twist of machine frames, road dust, lubrication difficulties, excessive friction, &c. Many other kinds of bearings were tried, and, finally, the ball bearing was proposed. It is true that such bearings had been suggested before this time, but the great difficulty was to produce a true and hard ball.

After much experimental work in the Midlands, a ball bearing was produced commercially—see Fig. 1—and added to pedal-propelled machines in the year 1876.* These bearings, costly and imperfect as they were, proved to the early cycle makers that they were moving in the right direction. The bearings had the necessary flexibility, and would run with little or no lubrication. Friction, too, was greatly reduced.

Attention now had to be turned to the production of steel balls in quantities, but the manufacturer had very little knowledge to draw upon in the production of true spheres.

The billiard ball maker produced a fairly true sphere, but not in metal, and of a much larger size than the bearing maker required at that time. There was a certain amount of turning of ball-shaped pieces at that date in the Birmingham brass trades, and some of the early ball turning tools seem to have been suggested by these trades. No doubt some ball turning was done on swivelling tool rests, such as were used for turning steam engine governor balls. A diagrammatic sketch of such a rest is shown in Fig. 4. Obviously, this method would not be quite suitable for turning small balls of the cycle bearing sizes; that is, about ¼in. diameter.

Some use, however, was made of the types of tools used with this rest and shown in Fig. 5. The first is a flat smoothing tool, the second a curved smoothing tool, and the third a tubular form of tool which cut on its inner edge A. For several years the form of tool shown in Fig. 6 was used. It was run into the rod as shown, and the corners were rounded off by the same tool. The ball was finished by the tools shown in Fig. 5. It is said that certain other crude forms of tools, shown in Figs. 7 and 8, were used in Birmingham, but just when and how long they continued in use it is now impossible to say.

These early efforts of the ball makers gradually led to the forms of cutters shown in Figs. 9 and 10. They showed some advance and a more accurate ball could be made. One disadvantage, however, still remained. A rather large "teat" or projection was left on the turned ball, and had to be filed off while held in a holder such as that shown in Fig. 11. This operation, of course, required great care to avoid making a flat on the ball.

In using the pair of tools, as shown in Fig. 10, a swing-over form of rest, as shown in Fig. 12, was sometimes used. A later scheme is shown in Fig. 13. In this method one half ball was turned on each side of the tool, leaving a teat or stem strong enough to prevent breaking off. The back tool was then run in and the ball cut off. The "teat" left was in this case very small, as this could be accomplished without the ball breaking off.

Fig. 14 shows another method which allows of the "teat" being entirely turned off on the one side, but still leaves a large stem on the other side of the ball.

Fig. 15 shows an improved method, in which a central steady is used. A roughing and finishing tool can be run in from the front of the slide and the parting-off tool can be run in from the back. This scheme came at a later date and led up to the "Hillman" machine shown in Fig. 16.

Fig. 17 shows a tool and steady sometimes used, but which frequently gave trouble by the jamming of cut-off balls between the tools and steadies.

At a considerably later date the form of circular cutter shown in Fig. 18 was introduced. This cutter on a rapid automatic machine gave a large output, and the "teats" which remained were quite small. A considerable amount of the heavy roughing to shape was done by the quarter circle of the cutter close up to the rod-holding chuck. The ball rod was then moved forward to a stop, the remaining half of the ball formed, and the previously made ball cut off and a small part of the ball formed at point x. The circular form of cutter allowed for numerous grindings before the cutter was worn out. This was a very good and efficient tool.

Fig. 19 shows a tool lay-out in which the object aimed at was to do all the cutting as close up to the holding chuck as possible. It had the disadvantages of requiring two moves forward of the bar to produce one ball, and also it required the rod-holding collet to be in very good condition, otherwise the second half of the ball might be very slightly excentric with the first.

Other Methods of Ball Making.

Up to about the year 1895 little was heard of ball making by methods other than turning for sizes of §in. diameter and less. By this time some makers began to give their attention to both hot and cold pressing on types of machines somewhat similar to heading machines, but in the Midlands of England turning from the bar was continued for some years.

Case-hardened balls were used to some extent in America, but to get satisfactory results very great care had to be taken with the choice of material (for purity), and the necessary depth of case had to be carefully watched. So much care, indeed, was needed that most makers considered that "right through" hardened alloy steel was in every way the better.

Fig. 16, to which we have very briefly referred before, was invented by the late W. Hillman, of Coventry. His object was to produce as perfect a ball as possible before the grinding process. Up to this stage, ball grinding had been an uncertain and haphazard process, as will be explained later. This machine ran successfully for many years.

It must be remembered that the Hillman machine was invented before the "Parkinson" wire feed and locking device came into general use. The Hillman machine had a travelling carriage or headstock, which revolved the ball rods and advanced them intermittently the required distance to form one ball at a time. The eight cutters (four fixed, four rotary) were fed by cam movement into the rods. One ball was finished and cut off at each complete inward movement of the tools and cutters. The finished ball dropped finally into the collecting tube.

The slight disadvantages of this machine were that the ball rods had to be drawn fairly close to size, to run correctly in the steadies, and the speed of the rods was too high for the rotary cutters. In spite of these defects it ran for many years with success. One drawback, viz., the comparatively complicated set of tools for such a simple profile as a sphere, would at first add considerably to the cost of ball production. By careful planning as to tool making, however, the tool costs were very greatly reduced. The shell rotary cutters were produced in quantities by a carefully planned tool set on a form of capstan lathe.

A machine also was devised, as shown by Figs. 16A, 16B, and 16C. This machine was so simple in action that a boy worker was capable of easily operating it and producing a large output of cutters in the "toothing" operation per day.

The cutter holder of the machine had a spindle with a taper hole to suit the taper of the cutters, and the lower end of this had a ratchet wheel which also acted as a dividing plate. Into this spindle was screwed an ejector for extracting the finished cutters.

A holding pawl actuated by a spring held the division ratchet, and consequently the cutter, in position, while the teeth were being milled.

The order of operations was as follows:—

The ejector screw was run back far enough to be sure of clearing the end of the cutter. The cutter was put in place and lightly tapped into the taper seat by a lead hammer. The feed handle was pushed over, and the tilted edge of the shell cutter passed under the milling cutter, and a tooth was cut.

On the return stroke of the feed handle the slide was brought right back till it met the screw stop. This brought the ratchet plate into contact with the stationary pawl, and the division ratchet and spindle were turned round the space of one tooth, meanwhile the holding pawl was made to slip one tooth by the incline on the ratchet teeth.

On the next stroke the ratchet wheel left the stationary pawl and the holding pawl again held the spindle and cutter while cutting the tooth. The ejector was screwed up to force the cutter out when all the teeth were cut.

The sketches Figs. 16A, 16B, and 16C show the general arrangement of the machine and an enlarged sketch of the ratchet and pawls.

The machine actually was a single-purpose milling machine of very simple build, and it proved itself to be quick and reliable.

The machine that followed the "Hillman" was of simpler build. It had a fixed headstock fitted with cam-operated "Parkinson" wire feed and locking device, and used a single cutter of the type shown in Fig. 18. Tool making on this machine cost considerably less than on the Hillman type, and less accuracy was demanded in the ball rods.

Works Examinations.

In a Midland ball factory the following examinations of the "work" as it progressed were made in the year 1891.

The ball rods were examined as soon after their arrival from Sheffield as possible. They were tested for size, roundness, and one or two were broken to note the appearance of the fracture. One or two pieces were hardened and broken and fracture-examined again. They were also file tested for hardness. The balls were tested for size to see that the right amount was left for grinding. Several checking tests were made while grinding proceeded. A few balls were broken in each hardening batch to note the fracture.

Finally, a few balls were broken to note the destruction load, and a file test was made here and there to test the hardness of the finished ball.

It will be noted that there were no deflection tests and other special tests that ball makers now use.

As before mentioned, balls were gauged into several qualities—first quality by "hole" and "eye" gauging to within about 0·0005in. The eye gauging was to check roundness. The second quality balls were allowed to vary by 0·001in. to 0·0015in.

Ball Grinding.

It is now necessary to consider the old methods of ball grinding. As rather less attention appears to have been given to this side of ball making, the grinding process naturally lagged rather behind the turning.

As might be expected, a simple and easy grinding machine, consisting of a pair of grooved plates, one fixed, the other revolving, and fed by an abrasive, such as emery and oil, would soon suggest itself, and Fig. 20 shows an arrangement of these plates, which, with slight detail alterations, continued in use for many years.

The top plates could be lifted off to examine the condition of the balls being ground. A surrounding metal shield kept the oil and emery from being flung away from the plates.

Now this scheme of grinding was at best a rather haphazard one, for it ground an under-sized ball as much as an over-sized one, and consequently the proportion of waste balls was rather large. Moreover, if a ball once took the "three-lobed" shape, it could never be brought back to the true sphere. The oval form also gave a great amount of trouble. These two shapes are shown in Fig. 21.

About the year 1887 some attempts were made to control the ball while being ground, and although not much was heard of this method in England, it is quite evident that this system contained the germ of a valuable idea. This method is shown at Fig. 22.

In 1890 a machine which had some very good features was invented. Fig. 23 is a diagrammatic sketch of it. It will be noticed that the grinding wheel is set excentrically, which ensures that the whole grinding face of the wheel passes over the balls at each revolution, thus preventing grooving, and tending to keep the face flat. This machine, however, was said to be troublesome to keep in order, on account of the design of the central plate, which was built up of segments, into the joints of which the grinding dust entered.

In 1894 another machine was brought out, which was free from certain objections of earlier machines, and yet retained all their good features. Fig. 24 shows the arrangement of the ball-carrying plates and grinding wheel. The size of the ball is definitely controlled, large balls only are ground, and the grinding wheel, being set excentrically, grinds across its whole face; the ball also while being ground is turned in all possible directions.

Fig. 25 shows yet another machine, brought out in 1900. Other machines were invented about this period, but most of them differed only slightly from the earlier types.

At this stage ball making had become a large and important business, both in Europe and America, with considerable competition and an increasing tendency on the part of the manufacturers to keep methods secret. In fact, some makers preferred secrecy to patenting their inventions, on account of the difficulty of discovering an infringement of a patent and opposing it when discovered.

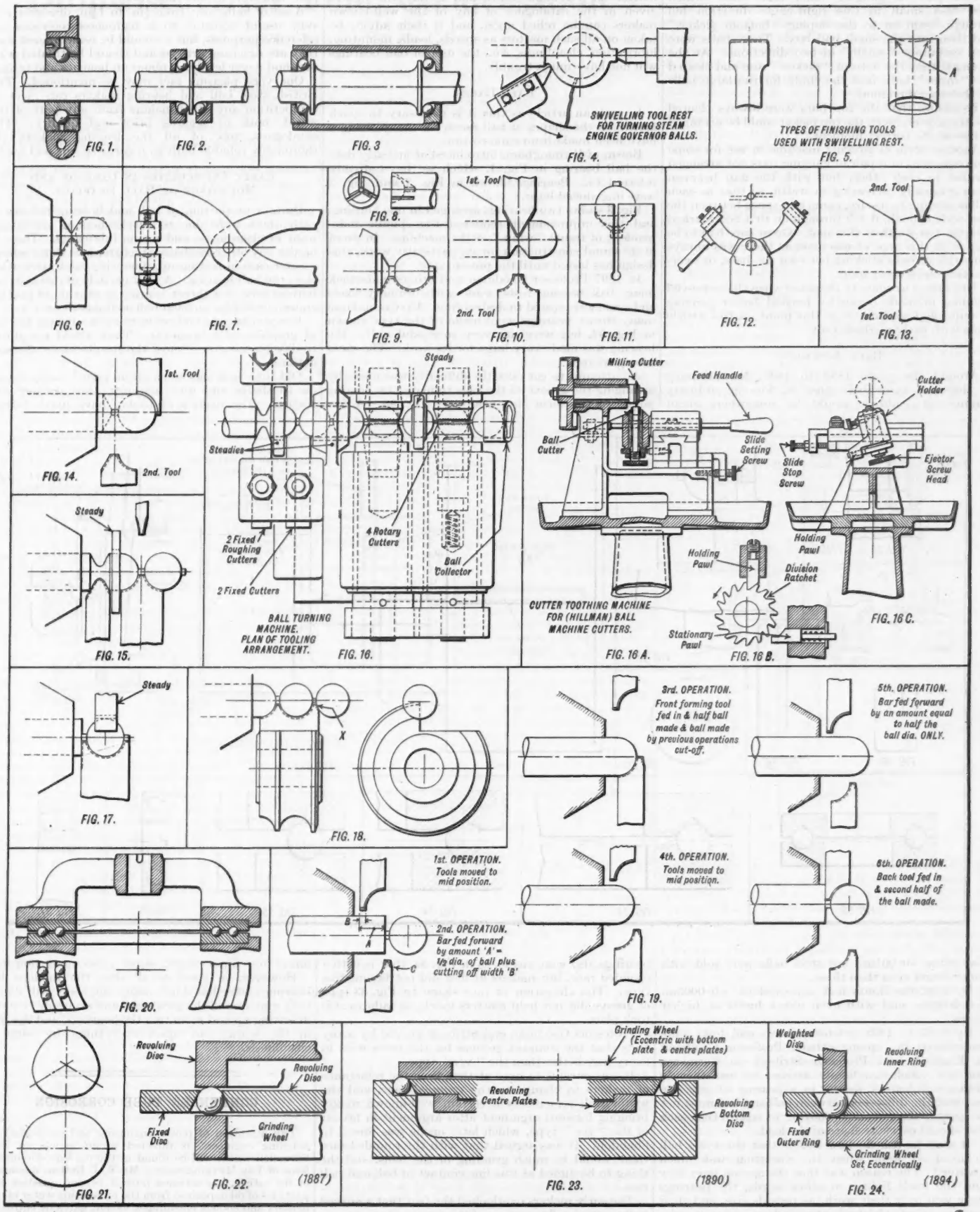
Turning Large Balls.

About the year 1894 engineers began to give their attention to ball bearings in heavier machinery, and steel balls up to about 1in. in diameter were beginning to be made in moderate quantities, the usual methods at this date being to turn from the bar up to 1in. diameter and to make over that size, say, 1⅛in. or 1¼in., from stampings when a sufficiently large order could be obtained. The stampings were made large enough to allow turning before grinding.

One method of turning was to employ a tool like that shown in Fig. 6, and finish with a rotary cutter as in Fig. 26. Another turning method is shown in Fig. 27.

* Bearings of type 2 and 3 were made later.

THE MANUFACTURE OF STEEL BALLS



"THE ENGINEER"

In this case the ball being turned revolves very slightly faster than the point tool in the holder. This very small amount faster gives the "feed" to the cutting tool and traces a series of cutting lines of the pattern shown.

It was claimed at this time that a ball with these cutting lines on it ground up truer than one made by method shown in Fig. 26, the tendency being for the ball to turn in all directions while being ground.

As time went on, larger balls were being asked for in quantities, and greater attention was being given to "precision" grinding, which we have already dealt with.

BALL GAUGING.

Early in the ball-making trade gauging of the balls was necessary, and "gap" gauges of the type shown in Fig. 28 were brought into use.

Another type sometimes used is shown in Fig. 29. This had a taper gap, marked at intervals to show the width at the different spots. The ball could then be tested for size, by trying at which mark it would touch both sides.

Another form is shown at Fig. 30. These were made sometimes slightly over and slightly under, giving a "limit" system. The gauges were marked accordingly thus, 0·249in., 0·248in., 0·250in., 0·251in., &c., for ¼in. balls.

This system of gauging was also used as "sight" gauging as a ball could be pushed into the gauging hole and held up to the light as a test for roundness. This method was continued by some makers right up to 1900, for best-quality balls.

About the year 1889 or 1890 the ball-gauging machine shown in Fig. 31 was brought out. This machine gauged the balls in two directions at right angles to each other, so that by passing the balls several times through the machine it sorted them into definitely large and small between certain limits. The machines could be arranged in a line, and each machine could be followed by another with a closer limit if desired. There were several ways in which these machines could be arranged, according to the gauging system to be followed.

This was the action of the machine.

On the left-hand side was a box filled with the ungauged balls. Working vertically in this box was a ball "picker," which rose and descended automatically. At each descent it filled with balls, and at each rise it discharged the balls on to the top pair of gauging bars. The balls discharged themselves by following the downward slope of the "picker." The large balls immediately rolled across the top gauging bars and fell into the box for the large balls.

These balls were definitely "large" in one direction. The small balls immediately fell through on to the second pair of gauging bars, and those which were also small in this right-angle direction fell through again on to the sloping "bottom picker," and then into the small ball box. These balls were then definitely "small" in two directions. At the arranged time the bottom "picker" rose and cleared the "large" balls into the chute for the large balls (in the other direction).

To ensure that the top bars were always cleared of balls at each cycle, the top picker could be arranged to rise at the correct moment.

Another form of gauging machine in use for some time consisted of a pair of gauging bars not arranged parallel to each other, but with the gap between them gradually increasing in width, so that as each ball according to its size, came to a space between the bars wide enough, it fell through on to a box marked with the bar width at this spot. Great care had to be used with this type of machine, as there was always some risk of balls sticking between the bars, or overshooting the correct spot.

This brings us again to the stage when the improved grinding methods began to demand better gauging systems, and we leave it at this point, as this article deals with early methods only.

Ball Accuracy.

Around the years 1889 to 1890, the accuracy of the steel cycle ball—that is, for the ordinary commercial qualities—would be somewhere about +0·001in. −0·001in., but steel balls were sold with wider limits even than these.

By 1892 the limits had improved to +0·0005in. −0·0005in., and with even closer limits at higher prices.

By 1897 to 1898 extensive trials and tests were undertaken by, among others, Professor Goodman in England, and Professor Stribeck in Germany, and the conclusion finally arrived at was that to obtain satisfactory results in a bearing of any size and load the difference between ball and ball must not be greater than about 0·0001in., to ensure that each ball should carry its share of the load.

It may be asked—how was it that the cycle ball behaved so well, when the variation was much greater? The reason was that the speeds were slow and the loads light; in other words, the bearings were well over their work, as regards size, and their running only for fairly short periods or intermittently. About the year 1920 or 1921 certain makers advertised steel balls guaranteed not to vary ball from ball in size and roundness by more than 0·00005in.—that is, by not more than one twenty-thousandth of an inch! This has since been proved to be very costly, and in ordinary cases not necessary. It is difficult to produce ball races of such great accuracy, and the settings and mountings cannot be depended upon to be to such fine limits. Neither can such measurements be made with an ordinary micrometer. Temperatures also then have to be carefully watched. We may take it, therefore, that for most purposes ∓0·0001in. is close enough.

Ball Loads.

In the early days of ball bearings for engineering work many disastrous failures occurred, and this is not to be wondered at. Ball sizes for given loads were worked out in many cases on the "crushing" load of the ball only, no notice being taken of "deflection," which occurs long before breaking. Since that date Professor Stribeck and others have put the matter on a reliable basis, and to-day the figures given in the catalogues of any of the well-known makers can be relied upon, and if their advice be taken on all such matters as speeds, loads, mounting, lubrication, cleanliness, &c., the user of ball bearings will not have much trouble.

Ball Races.

In such an article as this it is necessary to touch briefly on the shapes of ball races, for many changes have been made from time to time.

Bown, of Birmingham, introduced at an early date the ball bearing in Fig. 1, which we have already referred to. Bearings shown in Fig. 2 and Fig. 3 were introduced later.

Fig. 3 shows two bearings arranged in one housing, and this improvement rendered the spindle independent of frame "whip" of the machine. In proof of its sound construction for its particular work, this design has lasted until the present day.

In 1897 Professor Goodman and others undertook many ball bearing tests, some with ordinary loads and some were tested to destruction. Up to this time many thrust bearings were made of the type shown in Fig. 32, but were not very successful unless the bearing was made very large for its work. The races soon gave out.

An attempt to get over the difficulty was made by arranging the groove of the race to make the bearing points in the form of a cone—see Fig. 33. A few bearings also were made, as in Fig. 34, that is with a rounded race, but makers at first did not favour this type. The alteration of race shape to Fig. 33 type of groove did not help matters much, as failures still took place.

Professors Goodman and Stribeck proved by many tests that the rounded grooves for the races were in every way better than the "vee" type.

It was curious to note at that time the reluctance of makers to change to the rounded race, and the writer well remembers a certain well-known maker bringing forward argument after argument in favour of the "vee" type, which later on he was forced to abandon. It was argued that with the rounded race there would be much grinding of the balls, and the thing to be aimed at was line contact of ball and ball race.

The early makers overlooked the fact that a curved ball meeting a flat surface of the race made an appreciable width of contact, even without any heavy load; with a heavy load the width was considerably more.

The experimenters also found that with a curved race a much heavier load could be carried by the ball and the supposed grinding action was not nearly so serious as the makers had supposed.

The first races with round grooves were made with a fairly large radius, but it was later found that this radius could with advantage be reduced and a still greater load could be sustained by both ball and race—see Figs. 35 and 36.

Fig. 37 shows a form of race first made by the Skefko Company, but now made by others also. This was one of the earliest self-aligning bearings.

Uses of Steel Balls.

Considering its high quality, the steel ball is very cheap, and its cheapness is leading to many new uses apart from engineering construction. Its useful field seems to expand year by year, and to-day it is used in many toys and games where marbles of glass or porcelain were at one time used.

A set of balls, say, from ¼in. to 1¼in. diameter is a very useful addition to a high-class toolroom for reference purposes, but it should be remembered that they are precision articles and should be treated with care and never left lying about on benches and tables.

One very pleasing fact may be mentioned. The British steel ball and bearing makers can meet in competition any other makers from any part of the world, both as regards price and quality. The catalogues, too, of all the leading makers are thoroughly reliable both as regards speeds and loads.

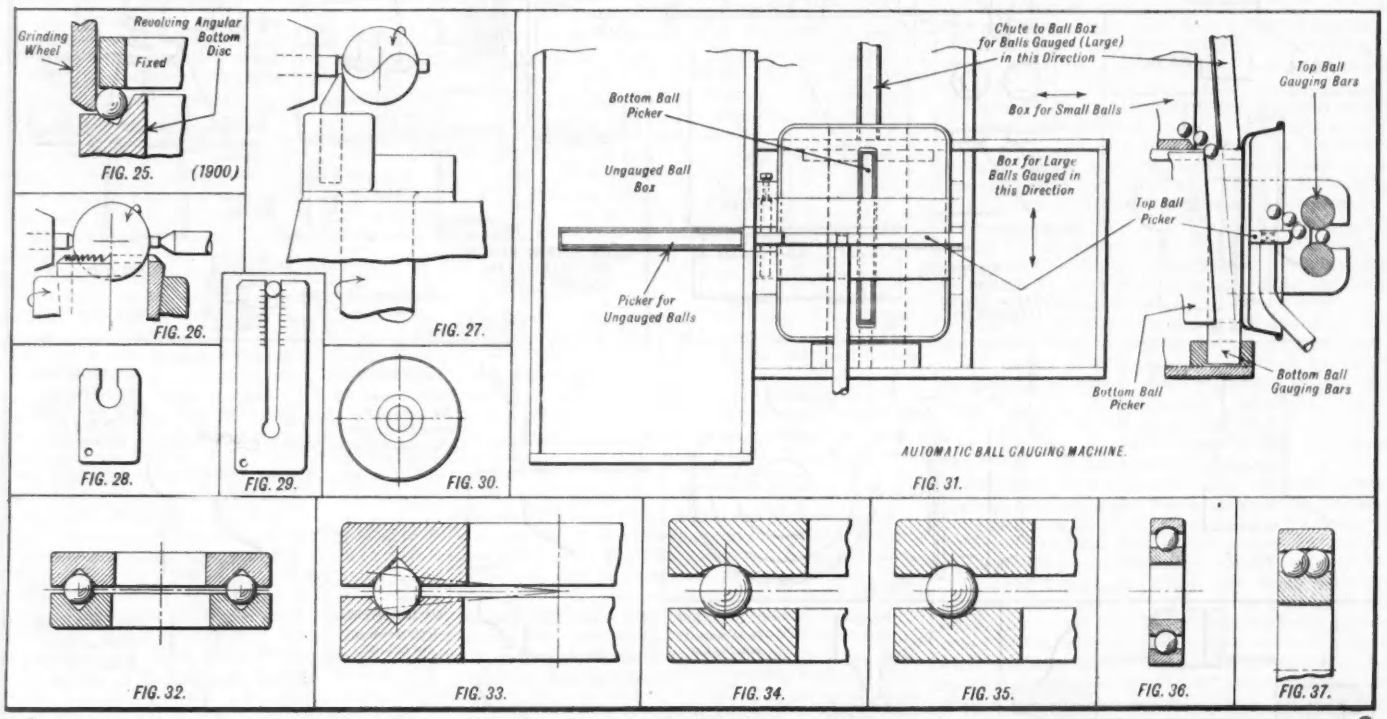
Early Difficulties in Care of and Mountings of Ball Bearings.

Quite a proportion of ball and bearing failures in early days were due to carelessness in mounting, want of cleanliness, and wrong lubricants. There is hardly any other mechanical contrivance that requires greater care in setting up, mounting, and lubrication than the ball bearing. A tiny particle of metal in the bottom race of a thrust bearing is capable of putting enormous strains on each ball as it passes over it.

Forty years ago makers were even advising the use of graphite as a lubricant. They would not do so to-day because they know the results of its abrasive action.

Old-time bearings were often very heavily forced on to shafts and into housings, thus causing distortion. The makers of to-day have fixed definite limits for inner races, outer races, and housings.

However, in spite of all that the modern ball bearing maker has done, many engineers still do not fully understand the great care and accuracy required in setting up and mounting the bearings, and the man in the works can upset everything by want of cleanliness.



"THE ENGINEER"

CONDENSER TUBE CORROSION.

THE attention of power engineers, and particularly of seagoing engineers, is directed to an article on Tube Corrosion which will be found in the current (December) issue of THE METALLURGIST. Mr. F. J. Bullen, the author of the article, has satisfied himself beyond question that particles of oil deposited from the circulating water in condensers and coolers encourages violent galvanic corrosion, which results in deep pitting of the tubes. It is not always easy to ascertain the origin of the oil, and Mr. Bullen discusses three specific cases. The last of these is concerned with corrosion of the tubes of oil and water coolers in lifeboats belonging to the Royal National Lifeboat Institution. Here, after a fruitless search in other directions, it was found that the tape packing for the tubes was soaked in linseed oil before being put into the stuffing-boxes. The oil, squeezed out when the gland was screwed up, set up pitting. The same trouble might arise with marine steam condensers, and the author recommends that tallow should be used in place of oil.

FOR many years Canada has been importing large quantities of slate from this country and the United States. It is reported in the *Engineering and Contract Record* that a large slate deposit near Madoc, Ontario, which extends to a depth of some 200ft. and of a quality said to be equal to the best Welsh material and superior to much of the slate found in the United States, is to be worked on a commercial production basis.

Dropwise *versus* Film Condensation.

By H. LEWIS, B.Sc., A.M.I. Chem. E.

THE condensation of vapours upon a colder wall separating the vapour and cooling medium, finds extensive use in surface condensers, feed heaters, and evaporators, and the question of their economic design is of great importance to industry.

In transferring heat from the vapour to the cooling medium, several resistances are encountered. The heat must travel by conduction through the layer of condensate which is formed on the metal surface, through the metal, and finally through the relatively stationary liquid film on the cooling side to the main body of the cooling liquid. Obviously, then, the rate of heat transfer will depend upon the rate of conduction of heat through the condensate layer; hence upon its thickness, and will thus be greater for vertical surfaces than for inclined surfaces, owing to the condensate being able to drain away more quickly in the former case. Nusselt—*Z. Ver. deut. Ing.*, 57 (1916), 199—in 1916 derived theoretical equations for predicting the coefficient of heat transfer between a pure, saturated vapour and a colder solid. Certain assumptions were made in the derivations, such as that streamline conditions existed in the flow of condensate, and that gravity alone was the cause of flow, neglecting any possible effects of the vapour velocity upon the condensate film thickness, which assumptions to a certain extent limit the practical applications of his results.

Experiments on the condensation of a pure, saturated vapour on the outside of horizontal pipes give results somewhat greater than those predicted by Nusselt, and this deviation is even greater in the case of condensation on vertical or inclined walls. One theory suggested is that these deviations are probably due to the beneficial effects of turbulence created in the condensate layer by a high vapour velocity. On the other hand, the presence of non-condensable gas in the vapour would lower the heat transfer coefficient.

Another theory advanced to explain the higher results obtained practically is that the condensate may not be formed as a continuous film, but may form as drops, which, on becoming large enough, drain from the surface in streams. The first extensive discussion of this probability is due to Schmidt, Schurig, and Sellschopp—*Tech. Mech. Thermodynamik*, 1 (1930), 5. These investigators studied the condensation of steam on a vertical water-cooled surface, taking photographs of the condition on the condensate side of the plate. The form of condensation obtained depended upon the condition of the plate. The steam condensed in a continuous film over the entire plate when the surface was either rusty or roughened by an etching process. On the other hand, with a highly polished surface of chromium-plated copper, dropwise condensation was obtained. With this type, the process of condensation begins with the formation of numerous droplets on a given area, which then coalesce, forming a large drop, drops up to 3 mm. in diameter being noted, and then the large drop slides off the surface, leaving an apparently bare surface for an instant. Drops then commence to form again on the bare surface. At any instant, a considerable portion of the metal surface is bare.

It was also found that dropwise condensation was obtained when the plate was coated with thin petroleum oil, but this was gradually washed away during the course of the experiment. Spoelstra—*Arch. Suiderind. Nederl.-Indie*, 3 (1931), No. 23—has noticed the effect of a small amount of oil in steam in promoting dropwise condensation, and found an increase in the heat transfer in comparison with results obtained from oil-free steam. Some experiments by Badger, Monrad, and Diamond—*Ind. Eng. Chem.*, 22 (1930), 700; see also *Ind. Eng. Chem.*, 22 (1930), 1103—on the condensation of diphenyl vapour outside a vertical nickel tube gave two to three times the theoretical heat transfer as calculated by Nusselt's equations, and this was attributed to dropwise condensation caused by the oily nature of the condensed diphenyl.

Schmidt, Schurig, and Sellschopp (*loc. cit.*) found that dropwise condensation gave heat transfer coefficients from four to eight times as high as those obtained with film condensation, *e.g.*, the heat transfer coefficient for film condensation was about 1230 B.Th.U. per hour per square foot per degree Farenheit, in comparison with values of 6150 to 8000 for dropwise condensation. Dr. Röcke has also reported, in a paper to the Heat Research Committee of the V.D.I., heat transfer coefficients of over 8000 B.Th.U. per square foot per hour per degree Farenheit with dropwise condensation. He sometimes found that on scaled tubes, drops and streaks of liquid occurred simultaneously, and he called this phenomenon "mixed condensation."

The question of the reason for the high heat transfer coefficients can be considered from the viewpoint of the resistance offered by the thickness of the condensate film. With a given rate of condensation, the heat transfer coefficient is inversely proportional to the thickness, and, if a and b are the thicknesses of the condensate layer at two adjacent spots, the conductance will vary as $\frac{1}{a}+\frac{1}{b}$, which is a minimum when $a=b$. Hence, the less uniform the distribution, the greater will be the rate of heat transfer—F. A. M. Wulfinghoff, *Mech. Eng.*, 55 (1933), 410. An attempt to utilise this idea had been previously made in 1924 by Ginat, who allowed the condensate from one tube to hit the tube below tangentially, but this arrangement was of doubtful utility. A factor tending towards high heat transfer with dropwise condensation is the fact that the particles impinge with an impact on the metal surface, whereas with film condensation there is an insulating layer of condensate.

With regard to the conditions necessary to obtain the desirable effect of dropwise condensation, present experimental results and knowledge are not conclusive. To a certain extent, the direction and velocity of the steam are determining factors, and drop condensation is most frequently observed with steam which is at rest or moving with low velocity. Thus, it has been observed that steam with a high velocity has a tendency to scour away the drops into film formation, but the drops are again formed on reducing the velocity of the steam. Kirkbride—*Ind. Eng. Chem.*, 26 (1934), 425—found, in some condensation experiments with water, gasoline, and α-bromonaphthalene on very smooth glass tubes, that drop-forming condensation occurred only with steam, and at very feeble condensate rates.

At what velocity of steam film condensation commences depends upon the condition of the metal surface. Jeffrey and Moyihan—*Mech. Eng.*, 55 (1933), 751—have recently carried out experiments on the condensation of steam on the outside of a horizontal copper tube. It is usually considered that drop condensation is a somewhat rare condition, yet Jeffrey and Moyihan find that a commercially clean copper tube gave dropwise effects, which they attribute to the presence of a thin film of lubricant, and that it was not necessary to have a highly polished surface or a low steam velocity, as stated by previous workers on this subject. If the greasy film was removed to give a chemically clean surface, the condensation changed to the film type, but this condition was unstable, and the slightest contamination acted as nuclei and produced dropwise condensation again.

They also carried out an interesting series of experiments on a 1in. outside diameter, 18-gauge condenser tube, made of Muntz metal, which had been in service since 1908. Some abbreviated results are given in the following table:—

Condenser Tube as Received.

Velocity of water inside tube, in feet per second	1·77	—	4·10	—	8·33
Overall heat transfer coefficient, in B.Th.U./sq. ft/hr./° F. diff. ..	250	—	318	—	384

Tube Clean on Inside Only.

Velocity of water inside tube, ft./sec.	1·78	3·03	—	5·22	8·36
Overall heat transfer coefficient, B.Th.U./sq. ft/hr./° F. diff	312	388	—	459	523

Tube Clean on Inside and Outside.

Velocity of water inside tube, ft./sec.	1·75	3·03	—	5·31	8·51
Overall heat transfer coefficient, B.Th.U./sq. ft/hr./° F. diff.	514	777	—	1152	1552

The tube, as received, gave 100 per cent. film condensation. When the water side (inside) of the tube was cleaned from scale, &c., the heat transfer improved somewhat, 100 per cent. film condensation still being obtained. When, however, the outside of the tube was cleaned of its oxide layer, the condensation changed to 100 per cent. drop, and the heat transfer coefficients increased tremendously. These figures illustrate strikingly the importance of a smooth surface on the steam side. When the outside of the condenser tube, cleaned in this way, was etched for sixty-six hours with a zinc chloride solution, the condensation changed to 40 per cent. film, with a reduction in the heat transfer. When the surface was made "chemically" clean by washing with nitric and chromic acids, 100 per cent. film condensation was obtained. It is thus apparent that the surface must contain some nuclei for drop condensation to occur, but not to be sufficiently rough or dirty for condensation to occur all over the surface, merging into film condensation. In actual use, a copper-base condenser tube becomes gradually coated with an oxide layer or with impurities derived from the steam, and as this occurs the condition of condensation changes from dropwise to film. Schmidt (*loc. cit.*) also noted the change to film condensation on the tube becoming oxidised.

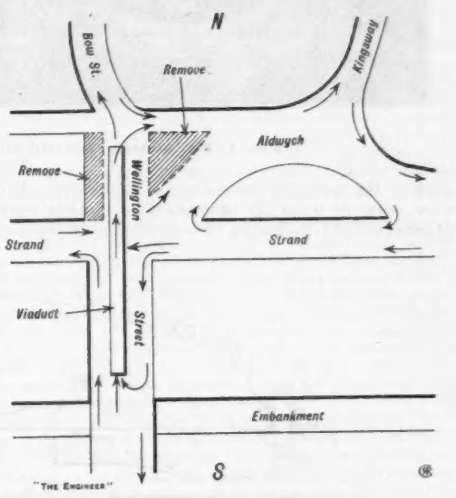
Drop condensation probably does not exist in industry because of the high rates of condensation and the rough surfaces usually encountered, but as to what degree of cleanliness or what steam velocity is necessary to obtain this desirable condition is still a subject for further research. Undoubtedly, very high rates of heat transfer have been obtained, and the questions as to what special precautions should be taken to obtain and what efforts made to maintain "clean" tubes on the steam side are of great practical importance. It may be more important to maintain a clean steam side than a clean water side.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

WATERLOO BRIDGE, NORTH APPROACH.

SIR,—Since Waterloo Bridge is to be widened for six lines of way, and traffic is to be diverted accordingly to make use of that space, what about the jam that is bound to occur at the Strand? Might I suggest that a main road be constructed from the Strand to the north end of Endell-street; that a viaduct be built, starting soon after the Embankment, and ending close by Lyceum Theatre. This viaduct should be wide enough for one line of traffic only (say, 10ft. to 12ft. on outside) and no footpath. The rise of the road by Lyceum is 10ft. above the end by Somerset House, so gradients could be quite easy. I would do away with old *Morning Post* building, and turn into a car park, retaining footpath in Aldwych. By following the arrows on enclosed rough sketch, it will be seen that the traffic



can practically regulate itself, without any cross clashing. The viaduct should be on the west side of the centre of Wellington-street, and not wide enough to allow a vehicle to pass another, thus avoiding all risk of collision and cars falling over side down below.

A main road to the north seems essential from Waterloo. Tottenham Court-road apparently should be the objective, but that seems overcrowded as it is, but in any case the road should be constructed till it meets Shaftesbury-avenue. As Wellington-street has been widened on west side south of Strand, the remainder on the north should continue so, cutting through the face of the Lyceum Theatre and as far as Tavistock-street. I should continue on same side, but that requires careful study. Beyond Covent Garden Theatre, up to Long-acre, widening should be on both sides to make convenient entrance to Endell-street, and I should preferably widen Endell-street on the east side as far as Broad-street. If considered advisable to go to Tottenham Court-road, High-street would have to be widened, and a system of one-way traffic for Oxford-street, Broad-street, High-street, and Charing Cross-road be introduced.

E. MOUL.

Woking, December 19th.

THE Minister of Transport has approved a scheme, submitted by the Staffordshire and Derbyshire County Councils, for the improvement of the ancient bridge over the river Dove at Mayfield, known as Hanging Bridge, at an estimated cost of over £33,000. Hanging Bridge is believed to date from the fifteenth century, and with the growth of vehicular traffic, it became necessary in the eighteenth century to widen the structure, segmental spans being added on either side of the original pointed arches, which are still to be seen. The bridge consists of two sections with a central causeway, and is weak, narrow, and awkwardly sited. The new and the old are ingeniously combined in the present scheme which provides for the construction of a new bridge on an improved line over the existing pack-horse arches, thus retaining the features of archæological interest. The new bridge will have a minimum width between parapets of 45ft., and will carry a carriageway of 30ft. with two footpaths. Both approach roads will also be widened, providing carriageways of similar widths.

Measuring the Uniformity of Machine Motions.

By HENRY E. MERRITT, D.Sc., M.I. Mech. E., M.I.A.E.

MANY machines and mechanisms of fundamental importance depend for their successful operation on uniformity of relative motion of the various members. In the simplest case of a pair of toothed gears, quiet running depends primarily upon uniform relative angular velocity of the two directly mating gears; the accuracy of the gears themselves, however, depends upon the uniformity of motion, either of rotation or translation, of a host of interconnected moving parts in the machine on which the gears are generated.

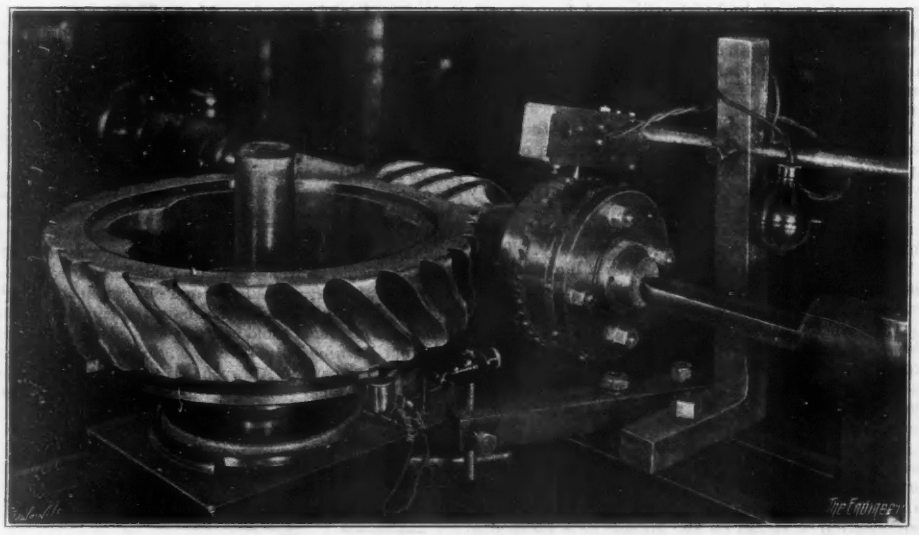


FIG. 1—MEASURING UNIFORMITY OF MOTION OF A WORM GEAR

In the case of a pair of spur gears some indication of the probable uniformity of motion can be gained from measurement of the accuracy of pitch and profile of the teeth, and it is not difficult to devise apparatus, embodying friction discs or tapes, to measure variations in the final motion when the gears are in mesh. When gears of more complicated form are encountered, however, measurements of pitch and profile errors cease to be reliable. Point-to-point measurements of pitch, for example, may be rendered quite useless by profile errors or by local imperfections in the tooth surfaces, and a gear can quite easily be better than a curve of accumulated pitch error might seem to indicate. On the other hand, it may be a great deal worse, for pitch measurements give no indication of the motion during each cycle of tooth engagement, *i.e.*, between the entry of successive teeth into action. This is particularly important in the case of worm gearing, where not only is the measurement of accuracy of wheel tooth profile commercially impracticable, but also the effect upon the final motion of measurable errors in the worm thread profile, division, and thread helix cannot be predicted. The problem becomes even more involved in a complicated machine tool, such as a gear generating machine, where the cumulative effect of errors in uniformity of motion in the dividing worm gears, dividing worm thrust bearing, fixed gears, change gears, differential gears, and feed screw is reflected in the product of the machine.

Step-by-step measurements of overall motion can in such cases be carried out, using more or less convenient apparatus according to the nature of the machine under investigation. This method, however, which may be tedious, is open to the objection that the machine has to be started and stopped between successive measurements, and the difference between the friction of rest and motion, combined with the elasticity of the various parts, may result in error.

With these considerations in mind, a method of measuring uniformity of motion has been developed in the research department of David Brown and Sons, Ltd., and has been applied extensively and successfully to the study of gears and gear generating machines. It is a modification of the method employed by the National Physical Laboratory, substituting for smoked glass the system of recording on celluloid introduced by the Cambridge Scientific Instrument Company, Ltd.

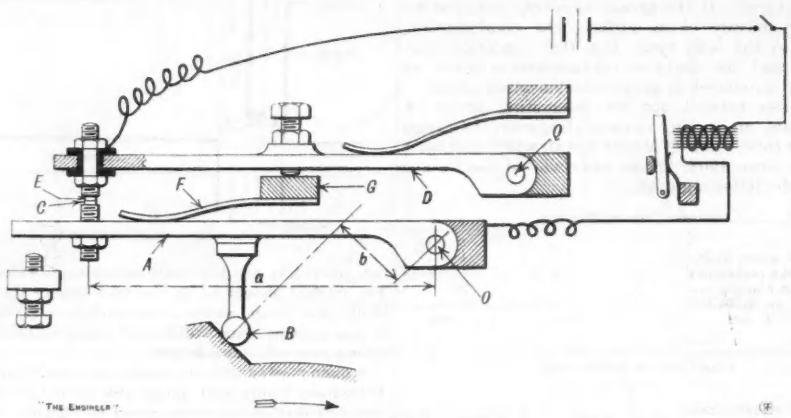


FIG. 2—DETAILS OF ELECTRICAL CONTACT MAKER

The principle underlying the process of measurement is as follows:—A series of regular electrical impulses controlled by a contact breaker on the primary moving member actuates an electro-magnetically operated stylus which traces a record on a strip of celluloid attached to the secondary moving member. If the impulses are uniformly spaced in relation to the motion of the primary member, the interruptions in the line traced by the stylus should also be uniform and any deviations from this uniformity can be measured.

The advantages of the method as a whole, assuming difficulties of detail to be overcome, are apparent; thus

(*a*) It is independent of the relative speeds or positions of the primary and secondary members or the number of intermediate elements.

(*b*) It will cover a complete revolution of the secondary member, if the motion is one of rotation, or of the full traverse, if one of translation.

(*c*) The record is easily prepared and handled.

(*d*) The machine being measured is not kept out of commission for an unduly long period, the measurements being made separately.

(*e*) The record is easily measured by optical projection, to a satisfactory degree of accuracy.

Having decided upon the principle, however, a good deal of experimental work had to be done before the technique of making and measuring the records was brought to the necessary degree of refinement. Handled with skill and experience, however, the records can be measured to an accuracy of one-tenth of a thousandth of an inch, and independent records made under the same conditions agree within one or two tenths. This is considerably better than was anticipated before the development of this method was commenced; measurement to within four or five-tenths was as much as was expected.

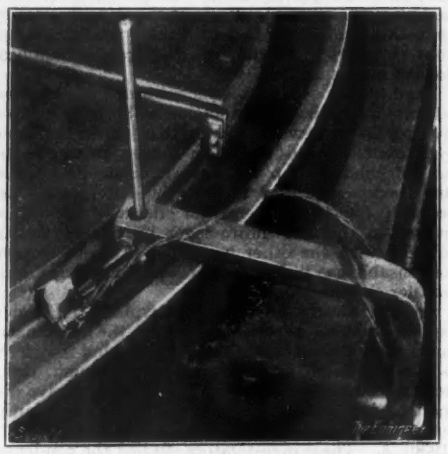


FIG. 4—RECORDER OPERATING ON A CIRCULAR TABLE

The Apparatus.—The electrical impulses are derived from a contact maker operated by a notched disc attached to the primary (rotating) member. The disc—seen in Fig. 1—is approximately 20in. in circumference, and has, in fact, two series of notches, giving respectively ten and forty impulses per revolution. The disc is mounted on a suitable adaptor and is provided with setting screws to correct eccentricity and reference surfaces for a final check.

The operative surfaces of the notches are inclined

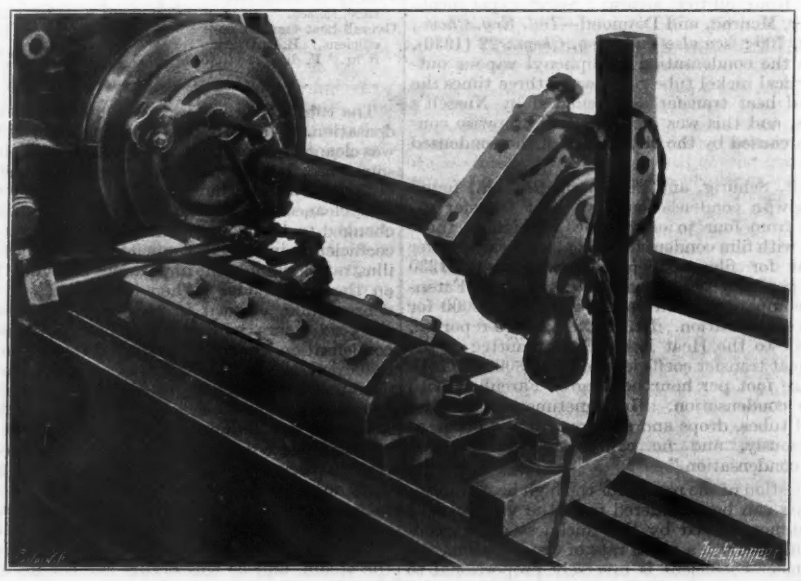


FIG. 3—MEASURING UNIFORMITY OF RECIPROCATING MOTION

at 45 deg. and engage a ball-ended extension of the contact-maker rocker. Contact is made when the ball is riding up the inclined face, and it is the interruption of the record when the contact is "made" that is measured.

The design of the contact-making mechanism is such that contact is made at an instant when the rocker is moving uniformly at about the middle of its travel, so that some lost motion must then be allowed to permit its further travel. The arrangement is shown diagrammatically in Fig. 2. The rocker A, pivoted at O, carries the ball-ended extension B and the platinum contact point C. The

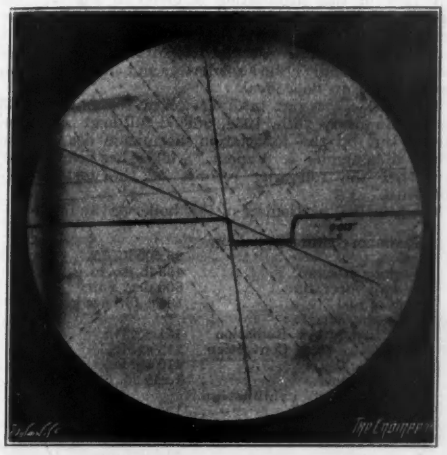


FIG. 5—MAGNIFIED IMAGE OF RECORD

follower D is pivoted at Q and carries the contact point E. The rocker A is held out of contact by a flat spring F, whilst the follower D is held by a similar spring against a fixed stop G. Thus, so long as no contact occurs, the position of the follower is determined by the fixed stop, and the position of the rocker at which contact is made is therefore constant. The pivoting of the follower, however, enables the rocker to continue its motion after contact has been made. The inclination of the notches increases the multiplication of the motion of the contact point C in the ratio of the dimensions *a* to *b*.

The stylus and celluloid strip are shown in position on a gear-hobbing machine table in Fig. 4. The stylus unit (made by the Cambridge Scientific Instrument Company, Ltd.), comprises a small electro-magnet, to the armature of which is attached a flat spring on which the steel stylus point is mounted. The motion of the armature when depressed by the current causes the stylus to move at right angles to the motion of the celluloid strip, tracing during motion of the machine a line of castellated form. When the celluloid is mounted on a rotating table, it is clamped to a cylindrical surface (which must be true to close limits) by a steel tape. The celluloid must naturally be of uniform thickness, and care must be taken to avoid straining it during clamping. Usually the strip is not long enough to embrace the entire circumference, and a record of a complete revolution must be taken in sections.

Fig. 3 shows the set-up when measuring the uniformity of motion of a reciprocating table, in this instance for the purpose of testing the relation between the motion of the table of a worm thread grinding machine and the angular motion of the work spindle. Here the celluloid is held flat by giving it a slight camber in a direction at right angles to its length.

Measuring.—In order to handle the record conveniently during the process of measuring, it is clamped between two strips of plate glass, and this also minimises temperature change effects. The celluloid must also be artificially aged in order to prevent change of shape between the recording and measuring operations.

The actual measurement is carried out on a Zeiss travelling microscope using the projector attachment. The image of the indentation produced in the surface of the celluloid is shown in Fig. 5. It will be seen that, consisting as it does of two well-defined dark bands with a light band between, it is very conveniently and accurately registered against a datum line. The actual readings are made by the micrometer head, and the results are reduced to the form of a curve of accumulated error.

Application.—The apparatus and method are clearly applicable to a wide variety of purposes, some of which have already been mentioned. In the case of a pair of worm gears, for example, it is easy to obtain a curve of accumulated error of angular position of the worm wheel for uniform rotation of the worm by mounting the notched plate on the worm shaft and the celluloid strip on a drum on the wheel shaft. Fig. 6 shows such a curve for a pair of worm gears having a ratio of 4 : 77, and indicates a periodic error of about 0·003in. per revolution of the wheel (equivalent to 0·0015in. excentricity), and an irregular superposed error per revolution of the worm of maximum amplitude of about 0·0012in.

Applied to a gear-hobbing machine, it is possible to determine not only the overall departure from uniform velocity ratio between the hob spindle and the work table, but the errors in any accessible intermediate drive, any group of change gears, or the motion of the hob carriage in relation to the rotation of the feed gears.

Application to non-uniform motions, such as cam mechanisms, also suggests itself, thus providing an overall check between the actual and the designed motion.

Finally, of course, the apparatus can be checked back on itself by mounting the drum carrying the celluloid strip direct on the notched disc spindle.

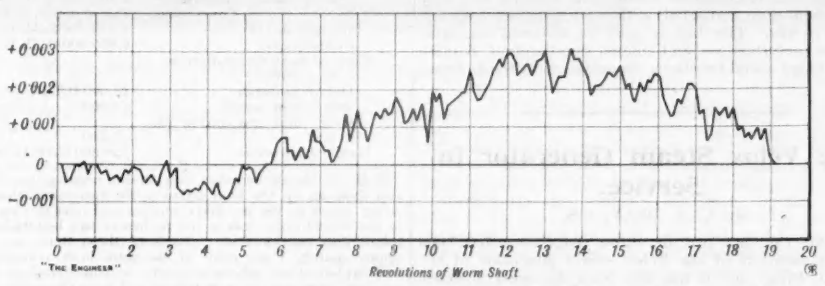


FIG. 6—CURVE OF ERRORS FOR A WORM AND WORM WHEEL

The Electricity Commissioners' Annual Report.

THE year ended March 31st, 1934, covered by the fourteenth annual report of the Electricity Commissioners, witnessed the first definite and sustained improvement in the general industrial and trading conditions in Great Britain. Although the improvement was less pronounced in those industries which are mainly or largely concerned in the export markets, the improvement extended to practically all trades and industries and led to a substantial increase in the amount of employment throughout the country generally. Another consequence was a notable revival in the demand for electric power in all the principal industrial districts. The monthly particulars of the output of public supply undertakings issued by the Electricity Commissioners show that the improved conditions had become definitely manifest during the summer months of 1933; that further improvement took place during the last three months of that year; and that such improvement was well maintained during the first quarter of 1934.

In the industrial areas covered by the regional grid schemes for Central Scotland and North-East England, in which the acute depression caused an actual decrease in the output of electricity for two consecutive years, the slight improvement recorded in 1932–33 was followed by a further increase in output in 1933–34, bringing the output in each of those areas nearly to the level attained in 1929–30. In the areas covered by the other regional grid schemes and in which the growth of output has been progressive in spite of the depression, the output in 1933–34 ranged from about 22 per cent. to about 100 per cent. in excess of that in 1929–30. The units generated by authorised undertakers in 1933–34 amounted to 14,175 million, an increase of no less than 1669 million, or 13·3 per cent. on the output of the previous year, and three-quarters of this increase took place during the last six months of 1933–34. It was the largest increase recorded in any year since the beginning of the issue of official statistics by the Commissioners in 1920–21.

Notwithstanding the severe check on the demand for industrial power supplies throughout the industrial depression, the electricity supply industry as a whole maintained an unbroken record of continuous expansion. The industry has been connecting new consumers at a rate of between 500,000 and 600,000 per annum, and its output, expressed in units generated, has grown from 10,526 million units in 1929–30 to 14,175 million units in 1933–34, an increase of 3649 million units in four years, representing an average increase of 910 million units per annum. The substantial nature of the electrical development which has taken place in this country under the difficult industrial and commercial conditions of the past four years is indicated by the fact that the output attained by the supply industry in 1929–30 was progressively exceeded in the four succeeding years by 5·1 per cent., 10·2 per cent., 18·8 per cent., and 34·6 per cent.

Outstanding events of recent years have been the rapid growth of the domestic load, the increasing extent to which electricity undertakings have provided facilities for the wiring of domestic premises, the installation of electrical apparatus therein, and the general adoption by authorised undertakers of two-part tariffs to enable consumers to make extended use of electricity for cooking, heating, refrigeration, and for other domestic purposes in addition to lighting. The returns made to the Commissioners by 631 authorised undertakers show that at the end of March, 1934, facilities for assisted wiring were being offered by 516 undertakers or by 82 per cent. of the total number. Facilities for the hiring of electrical apparatus were being offered by 435 undertakings, or 69 per cent. of the total, and facilities for the hire purchase of electrical apparatus by 480 undertakings, or 76 per cent. of the total number. As many as 527 undertakers, or 83 per cent. of the total number, had an all-in or two-part tariff in operation for domestic supplies. There are, however, still far too many different kinds of charges and tariffs in force in the various areas of supply throughout the country, and an important measure of simplification could be brought about by a reduction in their number and by greater uniformity in methods of charge. Inclusive of the Central Electricity Board, and allowing for the case of two companies with undertakings both in England and Scotland, the number of separate undertakers at March 31st, 1934, was 634, a net decrease of 16 on the number holding supply powers at the end of the preceding year. There were also four other statutory bodies not possessing powers to supply, but charged with definite duties of an advisory or supervisory nature in respect of the organisation for the supply of electricity in districts within their jurisdiction, namely, the Joint Electricity Authority for the North Wales and South Cheshire electricity district; the Advisory Boards for the Mid-Lancashire and East Midlands electricity districts respectively; and the Advisory Joint Committee for the South-West Midlands electricity district.

The units generated during the year 1933 showed a resultant increase of nearly 1308 million, or about 9·6 per cent. on the figure for 1932. The larger output was accompanied by an increase of 508,255 tons, or just over 5 per cent., in the amount of coal and coke consumed, but there was a falling-off of 5347 tons in the amount of oil fuel used at generating stations as compared with the previous year.

Stations of authorised undertakers were responsible for an increased output of 1310 million units, a growth of nearly 10·7 per cent. on the corresponding figure for 1932, public authority undertakers accounting for an increase of about 570 million units and company undertakers for an increase of 740 million. The output from the stations of railway and tramway undertakings also showed an increase of over 14 million units, but in the case of the remaining stations included in the returns there was a falling-off in the output of over 16 million units, of which over 3 million units were accounted for by the exclusion of the Guernsey undertaking from the returns.

The preceding figures and those given in prior reports show that the annual production of electricity at the stations, numbering about 500, included within the scope of the returns has increased from 5167 million units in 1920–21 to 14,963 million in 1933 and has thus nearly trebled within the course of thirteen years. During the same period the notable improvements in steam power station practice that have taken place have resulted in an all-round increase in the neighbourhood of 100 per cent. in the amount of electricity produced per ton of coal and coke consumed for that purpose. In the case of the stations of authorised undertakers the average number of units generated per ton of coal and coke increased from 663 units in 1920–21 to 1362 units in 1933, while the effects of the progressive improvements which have taken place during the past four years alone is shown by the fact that the average has grown from 1200 units in 1930 to 1362 in 1933, *i.e.*, by over 13 per cent.

The sales of electricity by authorised undertakers in 1933 reflected the definite improvement in industrial conditions that took place during the year and showed an increase of over 1009 million units, or 10 per cent., as compared with the figure for 1932. On the basis of the estimated population of Great Britain in 1933, namely, 45·26 million inhabitants, the sales of electricity from public sources of supply in that year thus represented an average consumption of approximately 245 units per head of population.

F.B.I. MISSION TO THE EAST.

THE report of the Federation of British Industries industrial mission to Japan and Manchoukuo was presented to the Council on Thursday, December 20th. It contains some important recommendations to firms with business interests in the Far East. In its report the mission states that it cannot urge too strongly that those industries or firms which are seriously interested in the possibilities of these countries should send out directors or responsible representatives of their own, to study the problems from the view of the particular industries which they represent.

The conferences showed that, in spite of difficulties, the encouragement of friendly industrial relationships was desirable. The mission found that a genuine spirit of friendship towards Great Britain existed in Japan, and it claims to have strengthened this favourable atmosphere by its visit, and by the formation of a permanent link between the central organisations representing industry in Japan and in Great Britain.

Following discussions with leaders in industry and finance, it was agreed, in principle, that it is desirable to set up committees of the Japan Economic Federation and the Federation of British Industries in Tokyo and London, to discuss questions affecting the industrial and commercial interests of the two countries with a view to arriving at a satisfactory solution. In connection with the rapid development work which is now taking place in Manchoukuo, the mission offered to the authorities the collaboration of British industry in the development of that state. A written assurance was received in return that the principle of such collaboration was definitely accepted. Concrete proposals in support of this principle will be submitted in detail to the mission in due course.

Doncaster Technical College.

RECENTLY there were opened by Lord Halifax important extensions to Doncaster Technical College, and on this page and page 644 we illustrate a number of the new rooms and laboratories.

More than sixty years ago there were classes in science besides art in Doncaster. Freehand and perspective drawing and machine construction were taught by Mr. Branston, a Day-school Master and an artist. History appears to be silent as to his attainments in machine design, and it was not until about seventeen years later that an engineer is to be found on the teaching staff of a growing school. It was about 1887 that Mr. John Small, an engineer on the staff of the Great Northern Railway

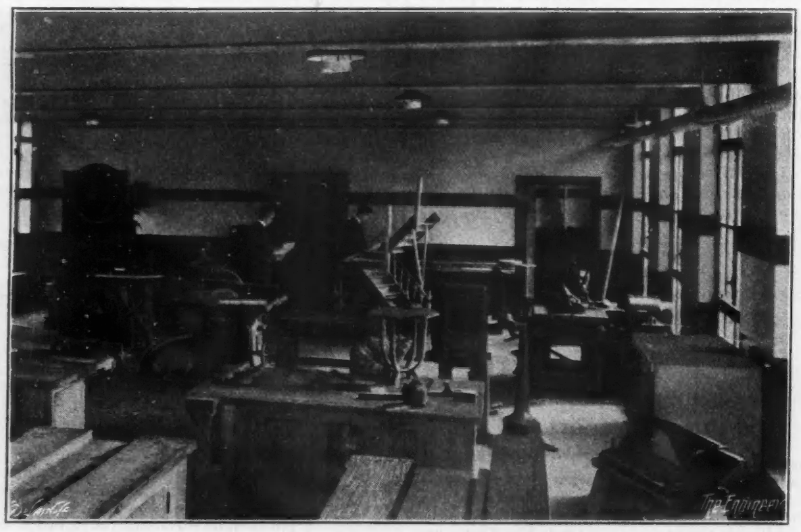


FIG. 1—WOODWORK ROOM

Works, began the teaching of plane and solid geometry and machine construction. For many years, however, although a technical education was obtainable, very little experimental work can have been done by the students. Mr. George Grace, who became Principal early in the present century, was an enthusiastic geologist and a great believer in the efficacy of the experimental method of training. He increased considerably the amount of apparatus available. For some years longer the classes continued to be held in various places in the town, principally in some of the rooms of the old Vicarage on the north side of St. George's Church, which was used as a girls' high school during the day. Shortly before the war, however, the "Old College Buildings" were designed, and in September, 1913, the foundation stone was laid. After the conclusion of hostilities the demand for a technical education developed rapidly in Doncaster. The discovery of the South Yorkshire concealed coalfield converted Doncaster from a market town, important

FIG. 2—50-TON TESTING MACHINE

industrially only on account of its railway works, to the central town of a mining district. Besides an influx of engineering students, there was also a rapid growth in the number of students requiring training in Mining. In addition to Engineering and Mining, the College provides courses in the Building Trades, Commerce, and the Domestic Arts.

On the engineering side the recently opened extension has provided an electrical laboratory—Fig. 3, page 644—equipped with a variety of suitable machines, all of the latest design. It is possible to generate various voltages and frequencies in A.C. work and various voltages in D.C., and to test both electrically and mechanically the different machines and still maintain control over every machine by the teacher at a special switchboard designed for the purpose. Close by there is a lecture room, while for the more elementary classes there is suitable electrical apparatus in the new physics laboratory. A large engineering and mining laboratory—Fig. 5—contains a locomotive-type boiler and a compound steam engine so arranged and designed that numerous experiments can be carried out. This power plant, which includes a surface condenser and air pump, was the gift of Marshall, Sons and Co., Ltd., of Gainsborough. Gas and oil engines, a Morris motor car engine, a two-stage air compressor, and various apparatus for the carrying out of hydraulic experiments are also included. In the same room a 50-ton testing machine—Fig. 2—and several smaller machines, are installed for the study of the strength of materials. An engineering workshop—Fig. 4—is equipped with up-to-date tools, and space has been left for a universal grinding machine and capstan and turret lathes when they shall have been acquired, together with electric heat-treatment furnaces. The needs of those students who intend to specialise on automobile engineering are met in another room, in which facilities for repair work and for testing are provided. This room adjoins the main workshop. In another room full-size plant and equipment for working with lead and brass and sheet metal up to ¼in. thickness is to be seen, and there are also a forge, bending rolls, shearing machine, punch and radial drill. Electric welding plant, both A.C. and D.C., and also gas-welding plant, is available. Woodworking has not been neglected, and the wood workshop—Fig. 1—is equipped with a planing machine, lathe, and band saw. The new chemistry laboratory, illustrated in Fig. 6, is equipped to take thirty-two students at a time.

Besides the educational rooms, the College has also a fine gymnasium and a hall with seating accommodation for 650 people. This hall is used for lectures, concerts, dramatic performances, and cinema film displays, besides various other social functions connected with the College.

The Velox Steam Generator in Service.

By E. S. DEAN, B.Sc.

DURING the last two or three years there has been frequent mention of the Velox steam generator in the technical Press, and it has also been discussed in detail in the papers given by Mr. Swallow before the Institution of Mechanical Engineers on March 27th, 1934, and by Mr. Adolph Meyer before the Institute of Fuel on April 25th, 1934. So far, however, few actual operating figures for units in service have been published. The two installations of which such data are here given were built by Brown Boveri and Co., Ltd. One is in the works of the Ste. Metallurgique de Normandie at Mondeville, in the North of France, and is fired with blast-furnace gas, and the other, oil-fired, is installed at the peak load station of the Soc. de Gaz et d'Electricté du Sud-Est at Toulon, South France.

The general principle on which this boiler operates is now well known, and in order to refresh the reader's memory, it will be sufficient to give a diagrammatic cross section—Fig. 1—of the blast-furnace, gas-fired unit at Mondeville. This diagram will be easily followed with the help of the legend. The design of the oil-fired boiler is in principle the same, but the gas compressor—7—is, of course, omitted, and the form of the burner is different. It is built into the top end cap of the boiler and fires downwards.

BLAST-FURNACE GAS-FIRED UNIT AT MONDEVILLE.

A view of this installation is given in Fig. 2. The separator will be seen on the extreme right of the figure, and to the left of this is the combustion chamber with the evaporator elements. On the left of the picture is the main auxiliary unit; the superheater and circulator pump are placed below floor level.

This boiler was put into service in November, 1933, and on Janurary 25th, 1934, official full-load tests were carried out by the Association Normande des Propriétaires d'Appareils à Vapeur, which has courteously permitted the following records of the tests to be published.

The principal particulars of this boiler are as follows:—

Maximum continuous evaporation		26,500 lb./hr.
Working pressure		455 lb./sq. in. g.
Steam temperature		800 deg. Fah.
Class of fuel		Blast-furnace gas
Heating surface:		
Evaporator:	Radiation	151 sq. ft.
	Convection	243 sq. ft.
Superheater		470 sq. ft.
Economiser		1,240 sq. ft.
Volume of combustion chamber		106 cu. ft.

Official Test Figures.

Evaporation		24,750 lb./hr.
Steam pressure (This is the present working pressure at the plant)		205 lb./sq. in. g.
Steam temperature		796 deg. Fah.
Feed water temperature		101 deg. Fah.
Flue gas temperature		235 deg. Fah.
CO_2 content of flue gases		22·2 per cent.
CO content of flue gases		0 per cent.
Weight of gas fired		26,515 lb./hr.
Mean calorific value:	Gross	1,345 B.Th.U./lb.
	Net	1,331 B.Th.U./lb.
Total power consumption of auxiliaries		160 kW
Boiler efficiency based on the net calorific value		92·8 per cent.
Overall efficiency based on the net calorific value, and including all auxiliary losses		87·8 per cent.

Analysis of Test Figures.

Heat absorption:		
In evaporator:	Radiation	4,200,000 B.Th.U./hr.
	Convection	16,850,000 B.Th.U./hr.
In superheater		5,540,000 B.Th.U./hr.
In economiser		6,850,000 B.Th.U./hr.
Rate of heat absorption in evaporator:		
Due to radiation		28,000 B.Th.U./sq. ft./hr.
Due to convection		70,000 " " "
Over total evaporator surface		53,500 " " "
Rate of heat release		330,000 B.Th.U./cu. ft./hr.

N.B.—It should be noted that, in determining the efficiencies and drawing up the heat balance, the heat equivalent of the power input to the auxiliary motors and also the heat added to the blast-furnace gas in the preheater (see below) have been taken into consideration. Each of these items amounts to approximately 1 per cent. of the total heat available. This will explain what otherwise might be considered to be a discrepancy between the heat release and heat absorption as given by the figures in the above table.

From the above figures it will be seen that the boiler has an astonishing performance, notwithstanding the fact that blast-furnace gas, with its low flame temperature, is not the most suitable boiler fuel.

It is also very interesting to note that the boiler uses gas with a comparatively high dust content, approximately

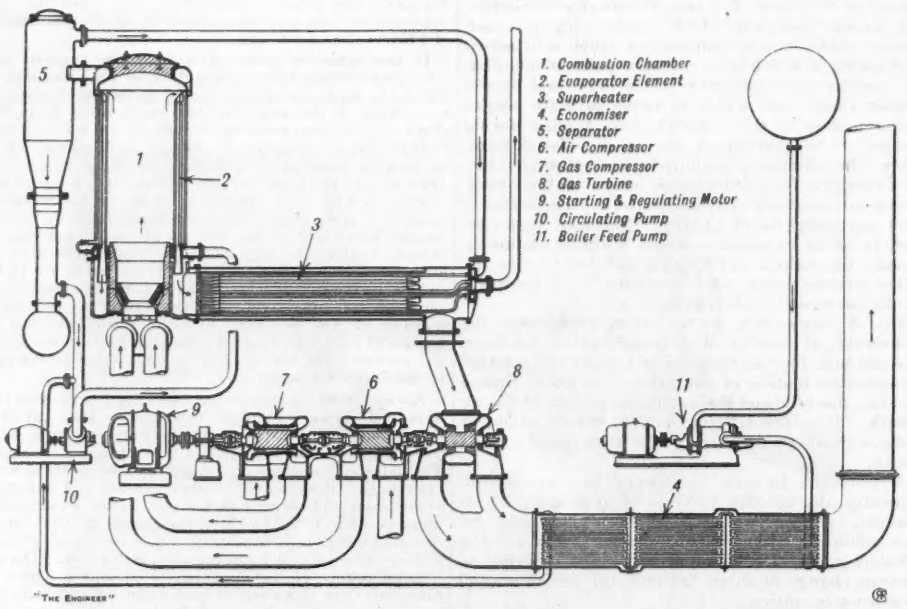


FIG. 1—DIAGRAMMATIC CROSS-SECTION OF "VELOX" STEAM GENERATOR

0·04 gr. per cubic foot. At the beginning this caused a certain amount of trouble, as this dust, together with free moisture entrained in the gas, formed a cement-like deposit on the blading of the gas compressor. This difficulty was overcome by installing a steam coil in the gas main to the compressor. In this way, the gas was preheated about 40 deg. Fah., and this prevented separation of moisture in the blading. The preheater mentioned in the note above refers to this steam coil.

It had been anticipated that the relatively high dust content might cause erosion owing to the high gas speeds in the compressor and turbine and over the heating surfaces. Careful examination of all parts of the boiler has shown, however, that, up to the present, there are no traces of any such erosion.

The Boiler Association, in the summary of its findings, speaks in very favourable terms of the operation of the unit, and states, furthermore, that it can be started up and brought up to full working pressure in ten minutes.

OIL-FIRED UNIT AT TOULON.

This installation is shown in Fig. 3, which brings out more clearly even than Fig. 2 the compactness of the Velox. The boiler was placed in service during February, 1934, and since that time it has been operating very satisfactorily. This particular plant is only worked in the evenings to take the peak load and, consequently, it has been possible to take full advantage of the rapid starting characteristic of the generator.

The official acceptance tests were carried out on July 31st and August 1st, 1934, by the Association des Propriétaires d'Appareils à Vapeur et Electrique du Sud-Est, and a summary of these tests is given below :—

Design data :	
Maximum continuous evaporation	55,000 lb./hr.
Working pressure	284 lb./sq. in.
Steam temperature	700 deg. Fah.
Class of fuel	Oil (Masut)
Heating surface :	
Evaporator : Radiation	242 sq. ft.
Convection	382 sq. ft.
Superheater	645 sq. ft.
Economiser	1,720 sq. ft.
Volume of combustion chamber	134 cu. ft.

Test Results.

Load, approx., per cent.	25	50	100
Evaporation, lb./hr.	14,470	28,900	53,900
Steam pressure, lb./sq. in. g.	257	251	231
Steam temperature, deg. Fah.	597	655	704
Feed water temperature, deg. Fah.	103	108	119
Flue gas temperature, deg. Fah.	171	205	235
CO_2 content of flue gases, per cent.	9·2	10·9	12·2
CO " " " " " "	0·1	0·2	0·1
O_2 " " " " " "	7·6	5·1	3·7
Total power consumption of auxiliaries, kW	54·3	49·2	78·7
Boiler efficiency based on the net calorific value, per cent.	93·2	95·2	94·7
Overall efficiency based on the net calorific value, and including auxiliary losses, per cent.	89·5	93·5	93·2

N.B.—To avoid any misunderstanding it should be mentioned that, in determining the overall efficiency, the heat equivalent of the auxiliary power has been taken at 4000 cal./kWh (15,850 B.Th.U./kWh). The overall efficiency of the Mondeville boiler was determined on the same basis.

In addition to the determination of the fuel economy, very interesting starting and flexibility tests were also carried out. To bring the boiler up to full pressure from cold required 6 min. 11 sec., and in a further 1 min. 20 sec. full evaporation was reached. In other words, in the astonishingly short time of 7 min. 31 sec., the boiler was brought up from cold to its maximum continuous evaporation.

In order to determine the flexibility of the boiler and its ability to take almost instantaneous load swings, a very interesting test was carried out. A 4000 kW turbo-generator, supplied with steam from the Velox boiler, was run light connected to the system. The unit, which was carrying the load, was then tripped out, thereby throwing the load on to the 4000 kW machine and Velox boiler The rigidity with which the boiler met this increase in load, which corresponded to an increase in the steam demand from virtually zero up to 65 per cent. of the boiler capacity, was such that no evidence of any disturbance in the system was noticeable.

Both of the installations here mentioned are in full commercial operation under normal industrial conditions, and even at Mondeville, where gas with a comparatively high dust content is being fired, no difficulty of a serious nature has been encountered. It is also interesting to note that, in spite of the depressed state of industry, six Velox boilers were put into service during 1934 and two during the preceding year.

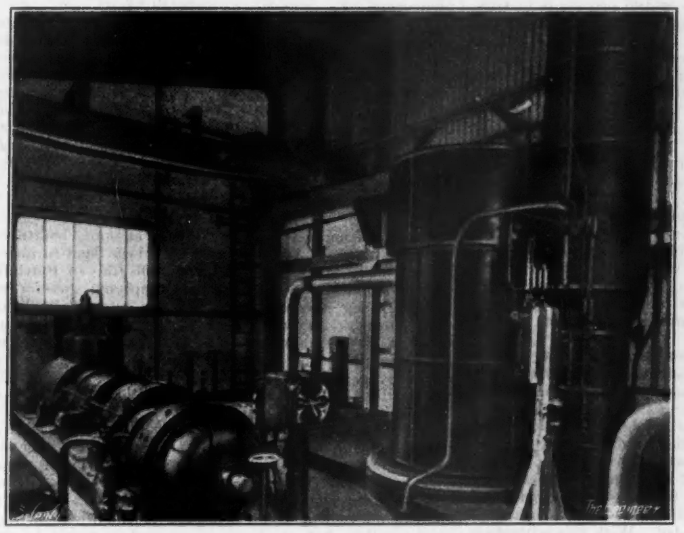


FIG. 2—BLAST-FURNACE GAS-FIRED "VELOX" UNIT AT MONDEVILLE

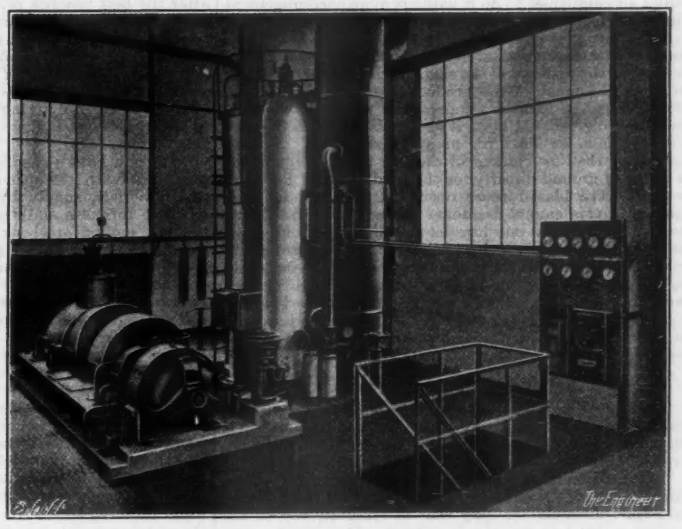


FIG. 3—OIL-FIRED "VELOX" UNIT AT TOULON

Revolutionary Changes in Steel Making.*

A STARTLING arraignment of the iron and steel industry has been made by a chemical engineer. It is a charge that not for seventy-five years has there been a significant change in either the theory or fundamental design of equipment. But accompanying the indictment is a proposal that the industry break away from tradition and approach the manufacturing processes along paths paralleling those taken in recent years by other industries.

The challenger is Charles F. Ramseyer, research engineer, Chicago District Electric Generating Corporation. His accusation takes the form of a paper presented through its iron and steel division to the American Institute of Mining and Metallurgical Engineers. The paper is scheduled for discussion at the New York meeting of the Society in February next year, and indications are that there will be considerable discussion. The paper in full is published in *Metals Technology*, for October, a publication of the Institute. From this preprinting is offered the following rather extended review of how Mr. Ramseyer looks at the steel industry, and what he believes it should do to improve its technological and economic status.

Underlying the author's discussion is the thought that in this period of seven score years or so process industries have been born and developed and others completely revolutionised, while the primary processes of making iron and steel are still carried out along lines laid down by Bessemer and Siemens and Martin, and subsequently expanded in the 1880's and 1890's to practically the modern scale by Carnegie, Schwab, and Captain Bill Jones. He explains the condition of the iron and steel industry in this wise : By the beginning of the twentieth century the industry had grown so large that no one man's interest in its technical development was sufficient to divert attention very far from the main business in hand, namely, that of making money "for its new owners, or at least for its controlling groups of financiers." "The general policy of the industry," he adds, "seemed to be to make as much money as possible, with as little risk as possible, and in this 'direct' pursuit of profit the search for improved processes languished."

Continuing in this vein, Mr. Ramseyer writes : "Changes were almost entirely confined to minor improvements in construction and the routine details of operation along lines already laid down. Such new things as there might be were either still-born or died of exposure before they had gained strength. With the growth of the country and the demand for steel, plants grew larger to conform to the size of the units in them, electricity was substituted for steam, and in mechanical ways, especially in the handling of material, a field in which America excels the world, the industry grew more efficient ; but its process equipment remained fundamentally the same in design as it had been for two generations."

Also : "While the oil industry went from batch to continuous processes and cut refining costs in two, steel continued to be made in the old-fashioned way increasingly in the open hearth." He regards the open hearth as a batch furnace "akin in principle to heating water by first pouring it into a saucer and then holding a candle flame close to its surface, except that with steel the additional precaution is taken of carefully covering it with a nice thick layer of slag, which effectively protects it from taking up heat efficiently."

CAUSES FOR LACK OF DEVELOPMENT.

As among the reasons that the steel industry failed to continue its early prodigious strides in process development, Mr. Ramseyer observes that "its long hours and hard life perhaps kept some of the more imaginative young engineers from its plants. Operating executives of exceptional intelligence and ability who rose to be officers of their companies were usually quick to see upon arriving in New York that they could make much more money in Wall-street than they could ever hope to obtain by developing new and better methods of making steel for their companies. The continued growth of the country and its demand for steel supplied sufficient profits so that competition was not too keen and there was no great urge to do much better.

"The non-technical bankers, lawyers, and financiers at the heads of the larger companies were against spending large sums on dubious experiments, and when they did attempt some experimentation they were frequently ill-advised and unsuccessful. From sad experience they learned how expensive high-temperature metallurgical development work could be, and they were loath to experiment in a field where millions were required to prove out new ideas. Their choice of operating executives naturally favoured men who had made low cost records, generally by avoiding all experimental expenditures and sticking to proved methods and equipment, as good operating men should do. Perhaps, too, the tremendous investment in plant made them apprehensive of the financial dangers of sudden obsolescence.

"The more highly trained technical men with time to think became largely fascinated by the new alloy steels, to the exclusion of other interests, though such steels represented, and still do, but a small part of the total steel tonnage produced, and the plants continued to be run largely by the more conservative operating men along the old lines. Moreover, no one of the larger companies was wholly owned and controlled by a single individual or small group, and none, even though it had the initiative and resources, could spend money on a large-scale process development without having to listen to the demands of its stockholders for dividends."

CONTINUOUS DELIVERY FROM BLAST-FURNACE.

The blast-furnace, Chemical-Engineer Ramseyer holds, should deliver molten iron continuously, and instead of the blast being air, a supply of oxygen should be given it instead. His favourable comments on the blast-furnace are that the handling of materials is well worked out and that it is thermally the most efficient of all steel-plant furnaces, in that it employs the technically sound principle of the counter-current utilisation of both heat and materials.

The first anomaly in blast-furnace operation, as he sees it, is that "despite a complete unanimity of opinion among blast-furnace men that the secret of successful operation is uniformity and regularity in the flow of materials to and from the furnace, no attempt has been made to remove the iron and slag from the furnace continuously. The water that collects in the blast-furnace gas mains drains itself off continually through water seals, but no effort to remove the molten iron from the furnace similarly through a liquid 'iron seal' has been made, though the advantages of such a constant knowledge of the quality of the product would be manifold.

"Large sums are spent on the construction of huge regenerative checker chambers, called blast-furnace stoves, of which each furnace usually has three or four, for preheating the air blast of the furnace, and yet ordinarily they are run far below capacity in order to have available at all times a reserve of heat to be used in case of need to control the temperature in the lower part of the furnace. Would it not be more sensible to use these expensive pieces of equipment at their highest efficiency and capacity at all times, and control the furnace temperature by adding a little extra heat directly to the hearth in the form of additional fuel as required ? Yet no comprehensive experimental work is being done along this line, so far as is known, in this country.

OXYGEN FOR COMBUSTION.

"Another and much larger field for development in blast-furnace work," continues the author, "is the use of oxygen instead of air for combustion. Much has been written on the subject, but very little done. The practical man usually has gone into it no further than to inquire whether equipment is available to produce the tremendous volume of oxygen required by a blast-furnace, and how much it would cost, and upon finding the cost apparently prohibitive has dropped the subject. But it has many possibilities. For one thing, it would greatly increase the capacity of a given furnace, and since the steel code

* From the *Iron Age*, November 22nd, 1934.

does not permit the building of new furnaces, this may turn out to be of importance for some growing company.

"It is not commonly realised that most of the present equipment could be used for oxygen without alteration by the recirculation of the top gas from the furnace with added oxygen until all nitrogen was worked out of the system. The gas-engine generators and blowing engines running on a gas-oxygen mixture would exhaust at blast pressure into the blast mains, thus increasing the blowing capacity, and the oxygen would be added to the blast either before or afterward to form a blast gas containing solely carbon dioxide (instead of nitrogen) and oxygen. Furnace temperature would be controlled by varying this ratio, the stoves being run at capacity at all times. The top gas would have more than twice the heating value of the present blast-furnace gas, assuming the same ratio of carbon monoxide to carbon dioxide, thus providing all the heating gas necessary for all other operations of the steel plant. The energy-carrying capacity of all blast-furnace gas mains would likewise be doubled. Since the process outlined would entail primarily the substitution of carbon dioxide for nitrogen in the blast, the blast volumes and other conditions would not change radically; therefore, most of the present equipment would continue in use.

"A proposal that offers so many advantages is well worth a searching and detailed study. The theoretical power required to produce oxygen from the air is low, and would be furnished in large measure by the present blowing engines, using the energy that now is required to compress the nitrogen in the air. Much development work would have to be done, especially on the oxygen end; but the steel companies can hardly expect the liquid air companies to do it without more encouragement than they have received heretofore.

"Another and increasingly troublesome problem with most blast-furnace plants, especially those close to urban centres, is the disposal of the slag, of which from ½ to 1 ton or more accompanies the production of each ton of pig iron. With the furnace temperatures available with the use of an oxygenated blast it should be possible to solve this problem, at least for many types of pig iron, by increasing the lime content of the slag to the point where it could be ground directly for the production of Portland cement. The blast-furnace operating man will reply at once that this cannot be done. But this has not been proved, because no one has yet intelligently tackled the problem with adequate backing in a serious attempt to solve it. Development work cannot be done effectively by people with regular operating duties, as has long been recognised in our more profitable industries, but not as yet by most steel companies. If any such work is done at all in the steel plant, it is usually done by the department superintendents in their spare time."

Scrap Melted in Shaft Furnace.

Turning to the open-hearth department, the author points out that the objects of the open-hearth are: (1) Melting, (2) treating the molten mass with a purifying liquid—the slag—and (3) finally separating the two.

"It accomplishes these objects by blowing down a flame on top of the metal to melt it and the slag materials, and then allowing the slag that is lying on top of the molten metal to react slowly with it. The minute non-metallic (slag) impurities in the metal rise slowly to the top, being lighter than the steel (just as dirt slowly settles out of muddied water).

"This inefficient method of heating two substances and letting them react without any positive method of mixing them, or of separating them after the reactions are complete, keeps even the best open-hearth furnaces from melting more than 300 tons or so of steel in a day, at a thermal efficiency of 10 to 15 per cent., while a blast-furnace can develop three or four times as much heat with an efficiency fourfold to fivefold greater. The fundamental difference is that a shaft furnace—such as a blast-furnace—operates both thermally and chemically on the counter-current principle, while an open-hearth furnace is but a batch kettle, and an extremely inefficient one in the bargain."

There is no intrinsic reason, in Mr. Ramseyer's opinion, why steel scrap should not be melted in an oxidising blast-furnace fired with oil or pulversied fuel, whereby the tremendous advantage of using a shaft furnace would be obtained. "A single furnace of that kind the size of a normal blast-furnace would have a scrap-melting capacity equivalent to a score of open-hearth furnaces, and it should cost only two or three times as much as one of the latter. Whole automobiles could be run into the top of such a furnace without any pressing or scrap-baling operation, and run out at the bottom a few hours later in the form of liquid steel scrap ready to be converted into high-grade steel, either by mixing and refining with molten pig iron, or with carbon by itself. This would dispose of the first function of the open-hearth furnace—the melting of the scrap.

Shaft Furnace for Melting Oxidising Slag.

"The second major function in steel making that takes place in the open-hearth furnace is the oxidising of the impurities of the charge and their elimination by absorption in the slag. As a means of forwarding the chemical reaction between the two materials by mixing, it would be hard to devise a more inefficient apparatus than the open hearth. In the first place, the metal must be kept molten by the heat from the flame, which can only reach it by passage through the slag, which is more of a heat insulator than a conductor; in the second, instead of the two reacting substances being intimately mixed in a state of violent agitation, as they should be, one lies more or less quietly on top of the other, the only contact between them being the single flat and relatively quiet interface.

"At the temperature of molten steel, the purifying reactions between slag and metal are almost instantaneous if the slag and metal are brought properly into contact with each other; but no use is made of this well-known fact. The open hearth takes hours to do what the Bessemer, by intimate mixing and violent agitation, does in 10 min. There is no fundamental reason why the oxidising basic open hearth reaction between slag and metal should not be similarly speeded up; nor, to go a step farther, is there any reason why the Bessemer process, which is a great improvement as far as it goes, should not be made continuous instead of intermittent.

"We have already seen that the steel-scrap-melting function of the open hearth may be performed with quadrupled economy in an oxidising shaft blast-furnace. Why not do the same thing for the slag, either in the same shaft with the scrap, or in a separate smaller slag-melting, oxidising shaft furnace? Here, again, there would be the advantage of the vastly greater thermal efficiency of continuous shaft melting as compared with batch heating.

Mixing and Separation by a Continuous Process.

"With molten steel scrap, molten pig iron and molten basic oxidising slag at hand, all produced continuously and uniformly at a constant predetermined rate in the most efficient possible manner, all that is left to do is to devise equipment that will mix the three together thoroughly, allow them to react, and then separate the mixture, in order to produce steel with but a fraction of the heat, capital investment and labour required by the conventional open-hearth process. The mixing of the three must be carried out continuously, not by any batch process; but this does not seem very difficult in view of the fact that molten steel is two or three times as heavy as molten slag.

"It certainly should not be impossible to devise a slag tower or column through which to drop the steel in a finely divided state, and to collect the metal at the bottom. This has already been done in part by Aston in his brilliant and revolutionary process for the production of wrought iron, which is now in actual commercial operation—the sole significant development in ferrous metallurgy since the Civil War! The purifying column process should be carried on in a counter-current manner, after the best practice of the chemical process industries, the nearly used-up slag meeting the most impure metal, while the nearly purified metal finally separates from the freshest slag. This would have the great advantage of decreasing the amount of slag necessary per ton of steel, and in the basic process would raise the phosphorus content of the spent slag high enough to enable its sale as a fertiliser, as is done with basic Bessemer (Thomas) slag abroad.

"We now have a chemically purified steel, continuously produced, with the utmost regard for economy of fuel and materials, simply by utilising the known efficiency of shaft furnaces and the counter-current treatment of the hot molten steel-pig mixture as it falls through a rising column of slag. The only function of the open-hearth furnace not discussed is the elimination of the non-metallic impurities, *i.e.*, oxides or 'dirt' left in the steel, which will necessarily be left over from the rapid and efficient, though violent, processing to which we have subjected our steel.

"The elimination of the dirt should not be difficult if we do not allow ourselves to be bound by the limitations of conventional practice. What do other industries do when they have a liquid contaminated by small amounts of other non-miscible liquids or solids? The filter press is out of the question; the particles are too finely divided, and there are no materials of which to construct a filter. But what of the separation of milk and cream or water and oil? They differ in density by very small percentages, while the dirt in steel is less than one-half as heavy as the metal in which it is suspended. With this advantage of a much greater difference in density, the centrifugal separation of the steel from its suspended impurities should be simplified. All that is needed is some man of the calibre of Captain Bill Jones, and the deed will be as good as done—and probably made into a continuous process as well. Has any steel company ever seriously (to the extent of a million dollars) proposed a joint investigation for the development of such a machine to a leading manufacturer of centrifugal separators? We doubt it.

"There are other treatments that might well be applied to steel; for example, passing it through a reducing slag to further purify it, and subjecting it to a vacuum to draw off the dissolved gases, which frequently cause a lack of soundness (blow-holes) in the final product. This development has already taken place on a small scale in some countries, and the outsider marvels that more has not been done with it. A number of simple methods of applying the principle in practice will immediately suggest themselves to almost anyone. If nothing better can be devised, let the whole casting process take place in a vacuum. Anyone familiar with the size of the huge vacuum chambers on the condensers of a large, modern steam turbine—big enough to hold a small cottage—can easily visualise such a process. This development may well be one of the first of the suggested possibilities to materialise. Even the 5000-year-old clay industry has started to vacuum-treat its raw material within the past few years."

In summing up this phase of the subject, the open-hearth furnace is described as "a most inefficient melting and mixing unit, and even as a settling chamber leaves much to be desired in the way of capacity. Too much time is required to let steel purify itself by just sitting still—no modern process industry would tolerate such a tedious method for a moment. So we may as well agree to its eventual abandonment. Such an irrational piece of equipment cannot hope to live for ever merely because its builders and operators are too lazy to make a change. The change will be forced on them."

Doing Away with Ingots.

In the finishing mills the author finds little to quarrel with. The smaller shape and section mills, he asserts, are marvels of mechanical ingenuity, running almost automatically at tremendous speeds and high capacities. "But it is still possible to be critical about the turning of liquid into solid steel, accomplished by casting the molten metal into huge ingots which cool so slowly that the originally homogeneous liquid metal is far from homogeneous by the time it has solidified. . . . If Henry Ford could show the world how to make plate glass from a continuous stream of the molten raw material, is it not at least conceivable that the same thing could be done with steel?

"A vastly different technique might be required, to be sure, but there is no reason to believe that insuperable obstacles would be encountered. It is purely a problem in mechanics, materials, and the flow of heat, and without question would yield to an intelligent attack. Ten years? Perhaps, but that is a short time to spend on a process capable of producing such tremendous savings. Nor need we limit ourselves to the continuous formation of steel plates. All small shapes and reasonably thin sections, up to an inch or so in thickness, should be amenable to continuous casting treatment. With the metals of lower melting points satisfactory experimental results have already been obtained.

"Let us hope that some day the blooming mill will be relegated to rolling finished heavy products and be no longer retained as a means of partly correcting the defects inherent in the present process of casting steel into ingots. To pour homogeneous molten steel into huge ingots only to roll them down again into smaller pieces containing imperfections, of which most can be traced back to the casting and freezing of the ingot, is absurd."

Cost of Research and its Rewards.

Ramseyer would not hold all "this stagnation in process development" against those in control of the steel companies of the world. High-temperature experimental and development work on a large scale, he points out, is extremely expensive. "Small-scale operation is not easily possible with molten materials that solidify in an instant when anything goes wrong, so that units at least half the usual size must be built if one is to proceed with any assurance of success. For every 100,000 dollars spent on the trial of chemical processes on a semi-commercial scale (and there are many) 1,000,000 dollars might easily be required in the high-temperature field. Sums of this magnitude are not available for experimental work by any but the largest companies which more often than not are quite content to let someone else do the pioneering. . . .

"No one can deny that the research staffs of the steel companies have turned out a vast amount of good fundamental theoretical work, but little of it has ever been applied to the development of practical equipment problems. Special steels, forming but a small percentage of their total output, tend to be studied to the exclusion of any new process development work on the production of the ordinary tonnage steels, which constitute nine-tenths of their total manufactures and on which a saving of a dollar a ton would yield truly fabulous returns."

An Ideal Plant.

In conclusion, the author touches at some length on an ideal plant. "We will start with two blast-furnaces, making 2000 tons of pig iron and 1000 tons of Portland cement clinker per day, besides supplying gas for all other heating purposes. Add to this a small oxidising shaft furnace for melting 2000 tons of miscellaneous scrap a day—'heavy melting scrap' would have no special significance for such a furnace. Add also a still smaller one melting 100 tons of oxidising slag, sold for the fertiliser value of the phosphorus it has taken out of the pig iron.

"The molten steel scrap and pig thus produced will be fed continuously down through a rising body of the oxidising slag and drawn off through a liquid metal seal at the bottom for centrifugal, vacuum, or other special treatment before going to the continuous-molten-to-solid-metal casting tank or mixer, from which the hot, solid, endless bar or shape issues and is rolled to size without the production of scrap. This is no wild phantasy. Half the details have already been worked out in other plants or processes, either for steel or other materials. To work out the rest of the problem would require merely time, money, and technical imagination.

"In such a plant, the open-hearth shop would be replaced by an investment of less than half as much; ingots and blooming mills eliminated altogether; the production of mill scrap reduced by 90 per cent.; one-third to one-half the present fuel requirements saved; not to mention a profit of a dollar or two a ton on the basic refining slag (fertiliser) and another dollar a ton on the blast-furnace slag (cement clinker). Such a plant, I believe, when smoothly functioning, would show a saving in the cost of steel or at least 5 dollars a ton.

"It can be done. The chemical process industries have demonstrated the correctness of the fundamentals, and steel making is essentially a chemical process. All that is required is the will and the money. Though development work on the whole project, when well under way, might easily cost 5,000,000 dollars a year over a period of ten years, or a total expenditure of 50,000,000 dollars, the saving at 5 dollars a ton in this country alone on a production of but 30,000,000 tons of steel per year would give an annual saving of 150,000,000 dollars or 300 per cent. on the investment. This return from process development on the 'tonnage' steels is far greater than can possibly be realised from the special alloy-steel development and production-control work in which most steel-mill metallurgists are engaged at present. . . .

"Perhaps the only place where there is enough energy, enthusiasm, and lack of respect for precedent to make such an undertaking possible is in the new and growing steel industry in Russia, destined some day, from the size of the country, the extent of its resources, and a constantly increasing demand, to be as great as our own steel industry has become under similar conditions during the past seventy-five years."

Of the ten experimental, non-skid sections on the new Kirkham by-pass, on the Preston–Blackpool road, opened recently, two sections, each of about 300 yards in length, have been laid by the British Road Tar Association under the ægis of the Ministry of Transport. The surfacing of one of the sections consists of two-coat tarmacadam, while that of the other is carried out in single-coat tar-concrete, British stone and tar being employed throughout.

The vacancy in the position of district engineer, Western District, Southern Scottish Area, London and North-Eastern Railway, created by the removal of Mr. J. C. L. Train to the Southern Area, as announced herein on November 23rd, has been filled by the transfer of Mr. W. Y. Sandeman from the adjoining northern district. That gentleman has been succeeded at Thornton by Mr. W. Russell, hitherto the chief assistant (construction) under the Scottish Area engineer at Edinburgh.

Railway and Road Matters.

THE appointment of Colonel Bressey to take charge of a survey of the highways of Greater London has led to the promotion of Mr. F. C. Cook, the Deputy Chief Engineer, to be the Chief Engineer of the Roads Department of the Ministry of Transport.

ON October 2nd one of the L.M.S. electrically operated trains from Liverpool to Southport ran into a motor road vehicle at an occupation crossing between Formby and Freshfield. One of the occupants of the motor lorry was killed, but there was no personal or material damage on the train. The accident was inquired into by Colonel Trench, one of the inspecting officers of railways, and as his consequent report deals with the general question of occupation level crossings, it is noticed herein in our editorial columns.

THE Railway Returns for 1933 show that for that year the average haul for freight traffic was 55·78 miles, as compared with 55·61 miles in 1932. The net ton miles per route mile were 746,008, as against 741,427, and the net ton-miles per engine-hour 451·37, as compared with 448·11. For all goods traffic, excluding livestock, the average receipt per ton was 6s. 4d. in 1933, as against 6s. 4¼d. in 1932. The average receipts per ton-mile were 2·097d. for merchandise, excluding classes 1–6; 1·021d. for minerals and classes 1–6 of merchandise; and 1·046d. for coal, coke, and patent fuel. The corresponding figures for 1932 were 2·161d., 1·028d., and 1·046d.

THE Ministry of Transport Railway statistics for September show that, when compared with the corresponding month of 1933, there was an increase of 1·8 per cent. in the number of passenger journeys and of 1·3 per cent. in the receipts from passengers. In freight traffic there was a rise of 7·1 per cent. in the tonnage and of 5·2 per cent. in the receipts. The freight train mileage was increased by 5·4 per cent.; the average train load rose from 124 tons to 125¼ tons, and the net ton-miles per engine hour from 450¾ to 464¼. The September statistics also give the figures for the first nine months of the year. There was an increase of 4·3 per cent. in the number of journeys; of 3·0 per cent. in the receipts from passengers and of 2·4 per cent. in all passenger traffic receipts. In freight traffic the tonnage rose by 9·5 per cent., and the receipts by 7·4 per cent. Coaching train miles were higher by 3·0 per cent. and freight train miles by 5·9 per cent.

ONE of the serious railway accidents that are associated with Christmas and the New Year was the failure of the original Tay Bridge on December 28th, 1879—fifty-five years ago. It is a well-known story of a structure that was, to quote the Board of Trade report, "badly designed, badly constructed, and badly maintained." It is, however, due to the memory of Sir Thomas Bouch, its designer, that it should be recorded that Mr. Joseph Parkinson said, in his presidential address at the Institution of Mechanical Engineers on May 1st, 1890: "The fall of the old (Tay) bridge and its consequences point a moral to all future engineers, and it is this—do not let others ever cause you to deviate from the principles or allow them to persuade you to let mere money be the guide as to strength in your work. If Sir Thomas Bouch had not been influenced by such means he would not have built the bridge he did, and his bridge would have been across the Tay to-day, and he might, in all probability, have been living now.".

IN 1928 the London and North-Eastern Railway, in its north-eastern area, commenced the replacement of the semaphore arms, and their spectacles, of some mechanically operated signals by spectacles only, which moved before an electric lamp of the colour-light signal type. The electric lighting power was obtained from primary batteries at the signal. The spectacle casting, in which are the red and green glasses, was moved lower down the post and fixed near to the level of the driver's eyes. The result was a mechanically operated colour-light signal, *i.e.*, one worked by wire, in the usual way, from a signal-box, with all the advantages of the colour-light signal as to the same indications, by colours, by day as by night and with a more powerful light than with the customary oil-burning lamp. A sequel to the latter result is that, as with colour-light signals, fog signalmen are dispensed with and the cost of signal maintenance is also smaller. There are now about one hundred such signals between Northallerton and Alnmouth, a distance of 85 miles.

IT was thirty years on December 23rd since an accident occurred which Sir Arthur Yorke, in reporting on it, said was, as far as the destruction of rolling stock was concerned, probably one of the worst cases of derailment in the United Kingdom. The scene was Aylesbury, on the Metropolitan and Great Western Joint Line, and the train concerned was a Great Central express, which mainly ran with newspapers. There was an unusually dense fog, and, presumably, the driver, whose knowledge of the road between Leicester and London was very limited, lost his bearings, and came upon the curve which then existed at Aylesbury sooner than he expected. The severity of the curvature may be judged from a speed limit of 15 m.p.h. being called for. It was, though, at the foot of a bank of 1 in 117 for 6½ miles, and the train approached it at 60 m.p.h. Six vehicles were entirely destroyed in the consequent derailment, and the *debris* was confined in a space between the two platform walls for a distance of 50 yards. Two enginemen returning home as passengers and the two enginemen of the train were killed. The driver had an excellent record, and was a total abstainer. He had not been over the London road for twelve months. One of the recommendations made by Sir Arthur Yorke was that the drivers' "road notes" should be signed in the presence of a responsible officer, who should first examine the man as to his knowledge of the road. Another recommendation was that the curve at Aylesbury should be improved; that was done by the entire reconstruction of the station. A third recommendation was that the distant signals for the approach to such dangerous points should be kept permanently in the "warning" condition. We would say as to that that there are objections to such a step, but the Great Western adopted the practice, and it is standard on that line.

Notes and Memoranda.

DURING the past year eighteen new tube wells have been sunk in Northern Nigeria to water at an average depth of 158ft. The cost has worked out at 7s. 3d. per foot completed.

A NEW insulating material, known as Onagote, produced, on a laboratory scale, in the Soviet Research Institute of the Rubber Industry, has a low specific gravity and insulates against heat and sound. There are two kinds of Onagote, soft and hard, and both have been made from imported rubber and from Soviet synthetic rubber.

EXPERIMENTING upon the effect of catalysts in the case-hardening of steel, Messrs. K. Iwase and W. Ota made cementation experiments at 950 deg. with wood charcoal and the addition of various alkaline and alkaline-earth chlorides. The best results were obtained with a mixture of 10 per cent. NaCl and 10 per cent. sodium and barium carbonates, cementite only being formed in the presence of gaseous cementation media. The depth of case-hardening increases with the rate of diffusion of the carbon through the iron.

THE addition of a mixture of barium oxide and barium carbonate, about half an hour before pouring, to electric furnace heats of ferrous metals improves the product and adds greatly to the life of the acid lining of the furnace, states a note in the *Iron Age*. It is also claimed that the presence of these compounds of barium produce a quieter and steadier arc. When high percentages of sulphur are present, the barium compounds are said to reduce appreciably the amount of sulphur in the metal. Less viscous slags are also produced, resulting in less slag inclusions in the finished products.

BORON, the basic element of boric acid, and ordinary carbon, such as occurs in coke, are now being combined commercially by the Norton Company, Worcester, U.S.A., into the hardest substance that has ever been produced by man, says *Machinery*. Boron carbide, as the material is called, has a compressive strength of 260,000 lb. per square inch. It is unaffected by the strongest acids and alkalies, has a coefficient of expansion that is approximately two-thirds that of steel, is lighter than aluminium, and is little affected by heat up to temperatures of 1000 deg. Cent. The new material has found an immediate use in the cutting and lapping of cemented tungsten carbides.

A REPORT of the Dutch Institute for Fuel Economy on the trials of an ash catcher describes the plant as being partly filled with water, through which spiral blades revolve and moisten and catch the ash floating in the air. The catcher was placed behind a Lancashire boiler with a heating surface of 537 square feet and in which fine anthracite and pressed coal were used as a fuel, in the proportion of 3 to 1, 305 lb. per hour being used. The catcher consumed 3036 lb. of water, in which 6·6 lb. of ash were found. It was found that slightly over 50 per cent. of the ash taken from the flue before the catcher remained on a fine screen of 400 meshes per square millimetre. Only 6 per cent. of the ash after the catcher remained on the sieve.

COMMENTING on the behaviour of coke in foundry service, in *Archiv für das Eisenhuttenwiesen*, Mr. E. Homborg points out that for use in cupolas and blast-furnaces the coke must be strong and hard, but not brittle. This kind of coke is fine grained, and the pores are small. It can readily be obtained in wide coke ovens by prolonging the coking time and reducing the maximum coking temperature. Although coke produced in this way undergoes crystal growth and further graphitisation in the melting furnace, it is relatively free from fissures into which the molten iron and slag can penetrate. It does not crumble, therefore, as the burden passes down the furnace; in addition, it has a higher reactivity due to its regular fine-grained structure, and thus accelerates the melting process.

HEAVILY loaded commercial aeroplanes require maximum power for the take off, and to achieve this, says a note in *Flight*, high-compression and/or supercharged engines are being fitted. These engines require a high octane fuel when full power is used, otherwise detonation and loss of power occurs. Fuel of a high octane value is expensive, but without it machines of this nature cannot get into the air with a full load. A solution which permits the use of full power when required, but which allows economy to be practised at other times, has been evolved by some of the American air lines. A small tank is fitted containing fuel of 87 octane value, which is used for the take off. For cruising the supply is changed over to the main tanks, which contain a cheaper fuel of only 80 octane value.

IN a recent paper on "The Detection of Small Flaws in Metals by Radiography," Mr. A. C. Warren discussed in detail the detection of cracks and "flakes," particularly in steel. He showed that the possibility of detecting cracks radiographically depends partly on their dimensions and partly on their obliquity to the X-rays, and that over a wide range of dimensions a criterion could be found from consideration of the area of cross-section of the flaws. The minimum cross section of a detectable flaw can be found by ascertaining the cross-sectional area of the finest wire, laid above the specimen, which could be detected on the radiograph. As an example of the minimum size detectable, Mr. Warren showed that in steel 1in. thick a crack of width 0·004in. and a depth exceeding 0·02in. can be detected with certainty.

IN a paper read before the Liverpool Engineering Society, Dr. F. H. Todd gave details of results obtained from the latest experiments on the effect of adding a "fin" to the rudder post of a ship. The rudder is usually carried on a square-shaped rudder post, which is subjected to considerable force through being in the propeller race. Experiments on models had shown that the propulsive efficiency of a ship could be considerably improved by shaping the rudder post so that it had a fairly sharp-pointed leading edge generally known as a "fin." Recent experiments carried out on a model of a cargo ship had thrown further light on the causes to which this improved efficiency was due. In one case—that of a coastal vessel—a gain in efficiency of about 7½ per cent. was obtained by substituting a fin for a square rudder post.

Miscellanea.

THE Minister of Transport proposes to allocate half a million pounds from the Road Fund for the rebuilding of weak road bridges.

THE United States War Department is planning to erect steel nets over the locks of the Panama Canal to protect them from aerial attack.

IT has been stated that the lead manufacturers of the Tyneside have succeeded in producing red lead paint in various shades, including browns, greens, blacks, &c.

THE "Minnewaska," sister ship to the "Minnetonka," recently beached for breaking up at Bo'ness, has been beached at Fyfe shore, Port Glasgow, also for breaking up.

ACCORDING to the correspondent of the *Daily Telegraph* at Hsinking, some 2000 miles of railway have been built within the past two years in Manchukuo by the Japanese.

THE "Slieve League," a new steamer built for the L.M.S. Railway's cargo service between Holyhead and Dublin (North Wall), was launched from Messrs. Denny's yard, Dumbarton, on December 21st.

THE Dutch air liner which recently gained second place in the air race to Melbourne, has been completely destroyed as the result of an accident in the Syrian Desert. The crew of four and three passengers were killed and a heavy mail load destroyed.

NINE Canadian firms producing natural abrasives had a production last year valued at 60,927 dollars. The products included 1789 tons of diatomaceous earth, produced in Nova Scotia, Ontario, and British Columbia, together with 499 tons of grindstones, pulp stones and scythe stones.

ACCORDING to Ministry of Labour estimates, at the end of November there were 10,212,000 insured persons in employment in Great Britain and the number of wholly unemployed was 1,729,838, with 309,643 temporarily stopped and 81,304 normally casually employed; making a total of 2,120,785.

AFTER experimenting for some months with a two-car train fitted with a special system of control, the London Passenger Transport Board has ordered a six-car set for further trials, says the *Electrical Review*. A feature of this principle is that regenerative braking can be used to a "dead" stop, and a further advantage is the elimination of switchgear contactors.

A NEW nitriding cast iron without aluminium has been patented in the United States. The approximate composition is: Total carbon, 2 to 4 per cent.; manganese, 1 per cent.; maximum silicon, 1 to 4 per cent., and chromium, 1·5 to 3·5 per cent. Tungsten up to 2 per cent. is optional and not over 1 per cent. of titanium, vanadium and molybdenum is permitted.

AFTER a series of experiments on the fireproofing of timber, it has been reported to the American Wood Preservers' Association that out of sixty-seven chemicals tested only four have shown a high degree of effectiveness in reducing both the flaming and glowing of woods. These are diammonium phosphate, mono-ammonium phosphate, phosphoric acid, and monobasic magnesium phosphate.

THE airship "Graf Zeppelin," returning from her Christmas cruise to South America, has completed 621,000 miles in the air, and has now crossed the ocean ninety times, says *The Times* Berlin correspondent. Launched in 1928, the "Graf Zeppelin" has spent nearly 10,000 hours in the air, made 423 flights, and carried 27,000 persons, 5,500,000 postal packages, and over 40 tons of freight without mishap.

DURING January the 1150-mile pipe line which the Iraq Petroleum Company has constructed between its oilfields at Kirkuk and the two terminals of Tripoli, in Syria, and Haifa, in Palestine, is to be ceremonially opened. The ceremonies will be five in number, and will take place successively in the five countries through which the pipe line runs, namely, Iraq, Syria, the Lebanon, Palestine, and Transjordan.

NEGOTIATIONS have been completed at Ankara between a German group headed by Krupps and the Turkish Sumer Bank for the establishment of an iron and steel works in Turkey under the Turkish Five-year Plan. A tentative agreement has been signed and the German group will give the Bank credit for £T9,000,000 if the work is entrusted to the group. No site has yet been definitely decided upon, according to the *Iron and Coal Trades Review*.

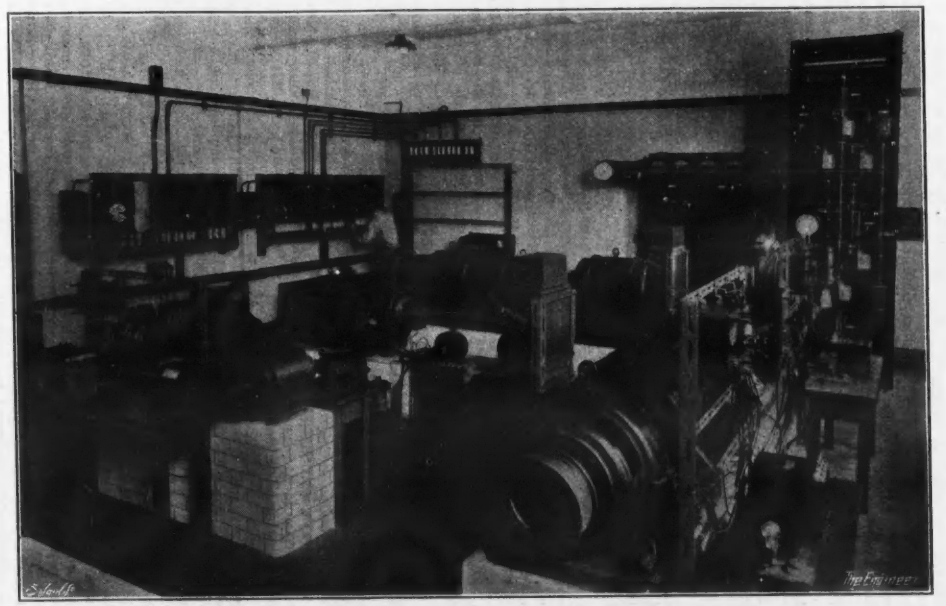
THE L.M.S. Railway announces that important schemes, at a cost of over £85,000, are to be put in hand immediately for the further improvement and modernisation of the West Coast Fishing Port of Fleetwood. The two main features of the scheme are the provision of six electrical belt conveyors for coaling trawlers and the conversion of the whole of the existing hydraulic plant at the port to electric power. In addition, siding accommodation will be constructed to take an extra 621 wagons.

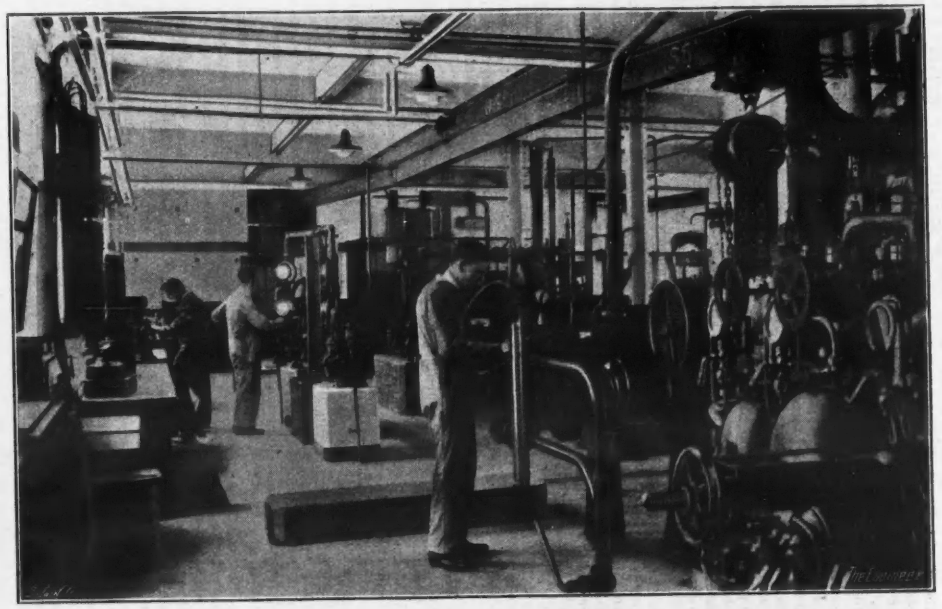
IN 1933 a total of forty-two coke and gas plants were operated in Canada, with a production valued at 29,936,975 dollars. The industry included eight by-product plants, two beehive plants, twenty-three retort or carburetted water gas plants, eight plants which made Pintsch gas for lighting railway cars, and one which produced acetylene gas for domestic lighting and heating. The Canadian Gas Association anticipates that this year's manufactured gas sales will reach a total of 17,000,000 cubic feet.

FOR the first ten months of 1934 the value of the exports of oil engines, excluding those for vehicles and marine work, from this country totalled £1,543,903, compared with £1,099,723 for the corresponding period in 1933. It is probable that the exports for the whole of 1934 will fall little short of £2,000,000, according to the *Oil Engine*. The total value of reciprocating steam engines exported for the first ten months of 1934 was £117,411 and of turbines £288,221. Of the oil engines exported this year, Australian imports account for £158,270, and India £289,652; 60 per cent. of the oil engines exported from the United Kingdom are despatched to countries of the British Empire.

EXTENSIONS TO DONCASTER TECHNICAL COLLEGE

(For description see page 640.)





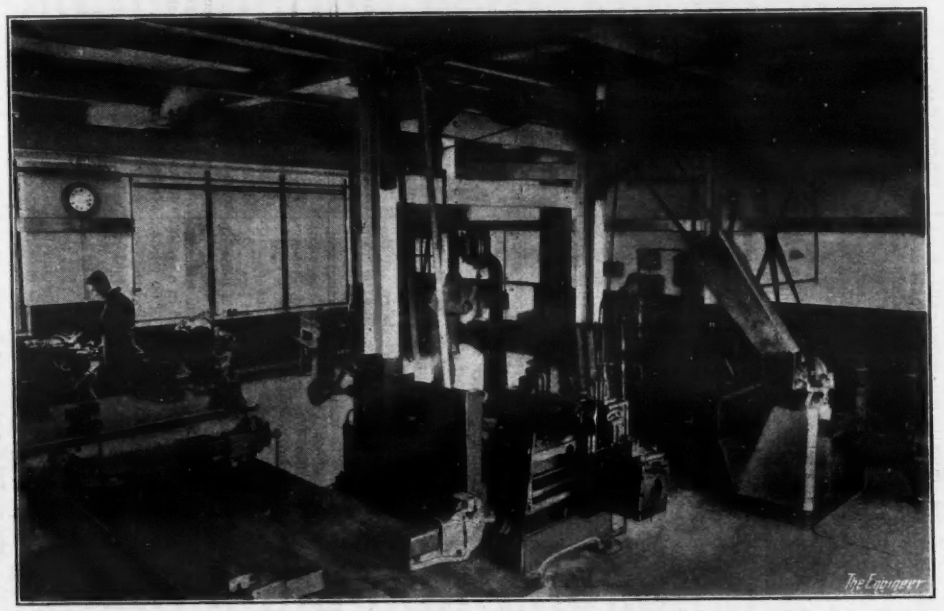


FIG. 3 (ABOVE):—ELECTRICAL ENGINEERING LABORATORY
FIG. 4 (BELOW):—ENGINEERING WORKSHOP

FIG. 5 (ABOVE):—ENGINEERING AND MINING LABORATORY
FIG. 6 (BELOW):—CHEMISTRY LABORATORY

The Engineer

DECEMBER 28, 1934.

VOL. CLVIII. No. 4120

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SIXTEEN-PAGE SUPPLEMENT—"THE METALLURGIST."

NOTICES TO READERS.

*** If any Subscriber abroad should receive* THE ENGINEER *in an imperfect or mutilated condition, he will oblige by giving prompt information of the fact to the Publisher, with the name of the Agent through whom the paper is obtained. Such inconvenience, if suffered, can be remedied by obtaining the paper direct from this office.*

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The Metallurgist.

THE DECEMBER NUMBER OF THE METALLURGICAL SUPPLEMENT TO "THE ENGINEER" ACCOMPANIES THIS ISSUE.

DEATH.

On December 14th, at Beckenham, Kent, JOHN PLACE, M.I. Mech. E., A.M.I.E.E., senior partner of Wheatley, Kirk, Price and Co., age seventy-three.

STEEL REORGANISATION PROGRESS.

IN many respects 1934 has been an historic year for the British steel industry; a new Constitution was adopted in April, which effected the gradual linking up of the various branches of the trade through associations, which in turn are affiliated to the British Iron and Steel Federation, has continued throughout the year and is still going on; the "independent Chairman" required by the Government has been appointed in the person of Sir Andrew Duncan; and, after interminable unofficial discussions, the Federation has met representatives of the Continental Steel Cartel and discussed the possibilities of an international agreement. Last, but not least, an application for additional duties which would give the British steel makers protection to the extent of £2 10s. to over £5 per ton in their home market, according to the class of material, has been put before the Tariff Advisory Committee. It will be seen, therefore, that the industry has been busy in other ways than making steel; but at the same time it has applied itself energetically to the task of putting itself upon a sound financial basis, in the case of a number of firms with marked success. It must not be supposed, however, that the work of reorganisation has advanced far; only the initial stages have been reached and some of the most difficult problems have yet to be solved.

It would be unfair to the steel industry to criticise too severely what has been done or left undone. A policy has been embarked upon which has received in some measure the approval of the Government and the whole-hearted support of most of the important interests in the industry. But it is regarded with anxiety and suspicion by many of the smaller concerns, and from it important branches of the trade have held aloof. Amongst the re-rollers, one of the most successful units has been able to carry on a successful fight to retain its freedom, and the sheet industry and the tin-plate manufacturers maintain an attitude of friendly independence. Progress, however, has been made in knitting the various sections of the industry together. An association of rollers and re-rollers has been brought into existence with the object of relieving the former from the competition experienced in pre-duty days and of ensuring the latter the supplies of raw material from home sources which they formerly obtained from the Continent. It is difficult to speak with enthusiasm of the success of this arrangement. The British steel makers have benefited to the extent that their production of semi-finished steel has greatly increased, but the re-rollers in the Association have had to raise the prices of their finished products to a point which, some of them complain, prevents them from getting business, and makes it impossible for them to compete with the unassociated firms and the importers of Continental steel. The steel makers also regard with anxiety the large imports of foreign steel which, this year had reached by the end of November a tonnage of 1,250,000, although this total related to materials which were not included in the negotiations, notwithstanding the duty of 33⅓ per cent. plus an additional barrier resulting from the low exchange value of sterling. The latter, it is argued, makes the actual duties well over 80 per cent. The application for additional duties was made in July, but the Import Duties Advisory Committee has not made public its decision. Instead it advised the industry to reach an agreement with the Cartel which presumably would embrace the home and export markets. The Committee was certainly placed in a somewhat difficult position, since the application did not receive the unanimous support of the trade. The meeting between representatives of the Federation and the Cartel naturally followed, since the latter organisation was itself passing through difficult times and an arrangement with the British steel makers would greatly add to its prestige. From all accounts little progress was made. On the export side the most that has been visualised so far is a vague understanding with regard to prices. In the case of the home market, with which the meeting was more nearly concerned, the discussion was barren of results. It is understood that negotiations will be resumed later; but that whilst the Cartel assumed a market for Continental steel in Great Britain of 1,000,000 tons per annum, the British representatives talked of a quota of 500,000 tons and would not listen to a suggested compromise based on a 10 per cent. cut. The position, therefore, remains unaltered; but it is understood that since the meeting the Federation has again asked for the higher duties. It is no secret also that the Continent has threatened a campaign in the export markets as a reply to the threat of higher duties. Some indication is afforded of what this would mean by the unprofitable fight for steel orders now going on in the Indian market between the British and Continental makers.

It would seem that the Federation has been chiefly successful in bringing together the steel industry and some of the consuming branches of the trade. In this way it is not only performing a useful service to the industry, but is laying a foundation for future co-operation. It is perhaps unfortunate that in doing so it has been necessary to adopt principles of price fixing, quotas, and similar methods of modern business which do not find general approval. The agreement between the constructional engineers and the steel makers provides an example. For years the former have complained of the competition of structural engineering concerns associated with steel works. It has been alleged that these firms obtained their structural steel materials on favourable terms. The arrangement provides for a schedule of prices for machining, &c., which will be observed by the constructional engineering trade, whilst that industry will also use steel produced by the associated steel makers. A feature of the scheme is said to be an arrangement by which structural firms which possess no works will be quoted higher prices for steel and for fabricated work. The constructional trade itself has formulated a kind of reorganisation plan, as reorganisation seems to be understood in the steel industry, and has devised a price schedule for the erection of various structures. The pool system has been adopted and a scheme of quotas formulated, with heavy fines for over-production and payments out of the pool for those firms which do not produce up to their allotment. For the time being, however, this latter scheme is in abeyance owing to a lack of agreement upon quotas. This, of course, is one of the main problems of the steel reorganisation scheme in all its departments.

Railway Level Crossings.

WE are led again to refer to level crossings by the issue, since we discussed the matter on December 7th, of the report by Colonel Trench, one of the inspecting officers of railways, on a fatal accident at such a crossing between Formby and Freshfield on the L.M.S. Liverpool–Southport line on October 2nd. This accident was a collision between a passenger train and a motor road vehicle at an occupation crossing, and was, as to its cause, similar to that at Wormley on November 27th, but the results were less serious. Whilst one of the two occupants of the road vehicle was killed, there were no injuries to the passengers or trainmen; there was no derailment, and only minor damage was done to the train vehicles. The circumstances in which the road vehicle got in the way of the passenger train are not, on this occasion, of general interest. But it is of interest to note that what was a farm road in 1867, for which only a local farmer had the legal use and for which a public notice is still displayed that "No cabs or vehicles other than farm carts allowed over this crossing," has become a general road crossing. This crossing, "for agricultural purposes only," is now used by twenty-five road vehicles passing through the large gates daily, and by some 300 cyclists and pedestrians using the wicket gates. The present report is of further interest in that it is dated November 12th, and was therefore completed a fortnight before the similar accident, which had much more serious results, at Wormley, the inquiry into which has also been undertaken by Colonel Trench.

The Liverpool–Southport line, at the point in question, runs due north-south; the sea is on the west side and the populated area on the east. The railway is crossed by an east-west main road at both Formby and Freshfield stations; at the former by an overbridge and at the latter by a public road level crossing. Within the, practically, 1500 yards that separate the two stations are three occupation crossings—Wick-lane, Barkfield, and College, 530, 975, and 1370 yards respectively from the overbridge at Formby. The accident occurred at Barkfield Crossing. As a good deal hinges, in these questions of level crossings, on the designation given on the parliamentary plans deposited when sanction was sought for the construction of the railway, it may be noted that, in contrast to the general experience of to-day, College Crossing was returned as a public road, but when the above-mentioned public road over the railway at Freshfield was made—which, to our own knowledge, was over fifty years ago—there was some agreement that the public rights at College Crossing should be waived in favour of that at Freshfield Station. Barkfield, as related in the preceding paragraph, is definitely an occupation crossing, which only one local farmer has the right to use. That fact was revealed on investigation by the railway company in 1925, which thereupon padlocked the main gates and gave one key to the farmer. The company received, however, a number of protests from various residents, and the padlocks were withdrawn pending further discussion. Here it must be explained that from Freshfield Station southwards there is, on the west or sea side, a narrow road which extends to 200 yards south of Wicks-lane Crossing, and Colonel Trench advises that it be made into a standard roadway, and thus permit the College and Barkfield crossings to be closed against vehicular traffic, and have wickets only for pedestrians. Wicks-lane Crossing is also legally an occupation crossing, with distinctly the largest user of the three. The daily average is forty-eight crossings through the big gates and some 350 pedestrians and cyclists through the wickets. Moreover, the roads leading up to it on both sides are now maintained by the local authority. This crossing presents a different problem. There was a collision between a train and a car there in 1932, fortunately without fatal results, and representations were then made by the local authority to the railway company and to the Ministry of Transport as to the risks entailed by these unprotected crossings. A matter of some moment is that there is a large school adjacent to Barkfield Crossing, the boys of which use that crossing, causing anxiety to the headmaster. As a result, the railway com-

pany prepared a scheme for providing warning signals, operated automatically by approaching trains, but to allow adequate time to open both gates and to cross, it was found that a warning period of four minutes was necessary. In view of the density of railway traffic in both directions, this long warning rendered the safe periods so few and short in the daytime that the local authority decided that the arrangement was not worth the expense which was estimated at about £500 initial and £36 annually. The railway company's officers were of the same opinion, and Colonel Trench adds that, after seeing particulars of the way the scheme worked out, he can only agree that that decision was reasonable.

These recent accidents have caused some concern over the legal rights of a railway passenger who gets hurt as a consequence of a collision between a train and a vehicle at an occupation crossing. At such a place, as our article of December 7th showed, a railway company has no responsibility for the use of the crossing. Who, then, is to compensate the passenger for his hurt? He has paid his fare to the company and expects safe transport, and it would be a poor answer to his claim to be told that the company has no liability. But if it were proved that the company was responsible for the safety of a passenger who had paid his fare, could the railway look to the crossing user for the refund of any claim so paid? Another point that we would raise is, Does not a railway company compromise itself when it provides any warning or other protection at an occupation crossing for the protection of which it has no specific responsibility? At Wicks-lane, mentioned above, the local authority, if the scheme had gone through, would have paid for the provision and upkeep of the warning signals, but if, as the coroner's jury recommended at Wormley, there should be some control by the railway over the use of the crossing, the provision of that control would place a responsibility on the railway for something it was under no legal obligation to furnish. That feature is mentioned in the present report, where Colonel Trench remarks that it would be an unfortunate position if a scheme to enhance safety should result in placing on its authors a liability to which they would not be liable if they left the matter alone. Again, the need for the control may be brought about by causes in which the railway company is not concerned. On that point Colonel Trench has something of interest to say. He observes that there are many cases in which extensive building development has taken, and is taking, place which relies largely on the use of old occupation crossings for access. He suggests that, before approving such schemes, it should be the duty of the local authority concerned to satisfy itself that the development includes the provision of adequate, convenient, and safe means of access, both vehicular and pedestrian. If that can be done it will, at any rate, put a check on the future creation of the more flagrant cases of unnecessary danger spots.

Literature.

The Principles of Motor Fuel Preparation and Application. Vol. I. By ALFRED W. NASH, M.Sc., M.I. Mech. E., and DONALD A. HOWES, B.Sc., Ph.D. Price 30s. London: Chapman and Hall, Ltd.

IN view of the extreme rapidity of technical progress on the subject of motor fuels, the need of a new treatise on the matter was becoming very apparent. During the last ten years we have seen the large-scale commercial development of cracking, the manufacture of stabilised gasoline, polymerisation, hydrogenation, synthetic fuel production, and the octane rating of fuels, to quote only some of the more obvious technical developments. Hence Professor Nash and Dr. Howes' book should find a ready welcome.

The complete book is in two volumes, the second of which is due to appear shortly. The first consists of over 500 pages of concise information, and is given over to the production of fuels, whilst the second will cover mainly methods of analysis and specifications.

As might be expected from these authors, the volume is very strong on the theoretical side, and will be of great use to the refining industry, since it gives the bulk of the mathematical formulæ required for such subjects as column design, heat interchangers, reactions for cracking, &c.

The distillation of petroleum products is described in the first two chapters, one of which deals with the principles of fractional distillation, steam distillation, and vacuum distillation; whilst the second describes fractionating, condensing, and heat exchange equipment. A special chapter is devoted to cracking, in which the thermodynamics and the mathematics of reaction velocity are of particular interest. Diagrams of the Cross and Dubbs liquid phase processes, and the Gyro vapour phase process are given as indications of technical design.

The stripping of natural gas and the stabilisation of casing head gasoline are described, whilst a lengthy section is given over to the refining of petroleum motor fuels. This section is very thorough and deals with all the processes which have attained any importance at the present time. A shorter chapter deals with storage, insurance, and distribution. The production of motor benzol, together with refining processes which are used specially for benzol, is treated separately from the refining of petroleum derivatives.

The hydrogenation of mineral oils and coals, a subject on which Professor Nash has been responsible for a considerable amount of research work, is treated concisely, whilst a brief description of the results obtained at the Baton Rouge plant of the Standard Oil Company of Louisiana is given, together with an account of the work of the I.C.I. The production of both methyl and ethyl alcohol is described, the former by wood distillation and by synthesis using the Methanol process, the latter both by the sulphuric acid process from ethylene and by fermentation. These are the subject of a special chapter in which the solubility curves required for the blending of alcohol fuels, together with the engine performance of the various mixtures is treated very fully. Legislation affecting the use of alcohol in various countries is here tabulated.

The production of motor spirits from oil shale, torbanites, and bituminous sands and by the low-temperature distillation of coal are described briefly. The same section deals with certain synthetic reactions and with the pyrolysis of methane, ethane, and propane.

The book is well indexed, both with a subject index and a name index. It should be of great value as a work of reference, both to the oil industry and also to those interested in the development and uses of the petrol engine.

SHORT NOTICES.

Elements of Water Supply Engineering. By Earle Lytton Waterman, M. Am. Soc. C.E. London: Chapman and Hall, Ltd., 1934. Price 21s. 6d.—Since the author, who is Professor of Sanitary Engineering in the State University of Ohio, explains, in his preface, that his work is in no sense a treatise or a handbook, but is frankly a text-book for students, it may be reviewed without the comments so often rendered necessary when the author of a book claims, or its title suggests, that it will appeal to various classes of readers. It may, however, be remarked that this volume might be very useful to an engineer in a remote district, who is expected to execute all and sundry engineering works. Since it is written for students having some knowledge of applied mechanics, materials of construction, and hydraulics, the author has not used any of his space or the time allotted to the course for which the book is adapted, to consideration, otherwise than in their application, of such fundamentals. The work is systematic and comprehensive. The thoroughness with which some of the relatively new elements of the subject are presented will convey to the student a sense of the manifold qualifications required of the water supply engineer. He must be able to forecast changes in populations served; must study health statistics and the data of epidemics; intelligently control bacteriological and chemical examinations of water; and understand the chemistry of filtering, sedimentation, and purification. The chapters on Precipitation and on Ground Water may suggest to him that systematic study of meteorology and geology, might better serve him than attempts to master otherwise the facts and data required to solve certain problems. The chapter on waterworks finance introduces the student to another of the burdens carried by the engineer, but although the importance of professional responsibilities and technical qualifications other than those of engineering character, is thus made evident, no undue proportion of the book is devoted to those aspects of the subject. Adequate information and instruction are given in respect of planning, the design and construction of works, and the operation of a water supply system, including the principal variants, in the source and the manner of collection or diversion, in the means of conveyance, and in the treatment which the character of the water makes necessary.

Neon. By S. Gould. London: Crosby Lockwood and Son, Ltd. Price 7s. 6d.—The use of neon signs for advertising purposes has led to the need for a more widespread knowledge of the properties of neon gas. In this volume the author describes what neon is, discusses briefly the manufacture of neon tubes, and deals with many items of interest to those who are engaged in the neon sign business. As far as possible the use of technical phraseology has been avoided, and the average practical man will find little in the book he cannot understand. The brief title "Neon" is, perhaps, somewhat inadequate, for it does not give a true idea of the field which the volume covers. The electrical side of the subject has not been neglected, nor has the author failed to consider the control of neon signs or their installation. For the most part, however, the volume is devoted to the tubes themselves, which have made great progress since the war. That there will be developments outside the field of advertising the author feels sure. The application of neon as a secondary interior lighting medium is receiving attention, and its use for aircraft signals is increasing. Although this is not the first book that has been published on the subject, it should appeal to practical men who are seeking guidance in the manufacture and installation of neon tubes.

The Ford Models V8, B, and A Cars. By V. W. Pagé. London: The Technical Press, Ltd. 1934. Price 15s. net.—All motor car owners are—or should be—familiar with the service manuals issued with the various makes of cars, but Ford owners are fortunate in having at their disposal what might be classified as a super manual dealing with every detail of their cars. Containing some seven hundred pages of matter, this book with its many illustrations and easily understood instructions will be found valuable by all interested in the upkeep and repair of the V8, B, and A model Ford cars.

BOOKS RECEIVED.

Minerals Year-book, 1934. Washington, D.C.: Superintendent of Documents. Price 1·75 dollars net.

British Rainfall, 1933. London: His Majesty's Stationery Office, Adastral House, Kingsway, W.C.2. Price 15s. net.

Electric Power Metering. By A. E. Knowlton. London: McGraw-Hill Publishing Company, Ltd., Aldwych House, W.C.2. Price 24s. net.

Bulk Handling of Wheat. By L. Lloyd Mercer. London: Oxford University Press, Amen House, Warwick-square, E.C.4. Price 1s. 6d. net.

Advanced Surveying. By A. H. Jameson, M.Sc. London: Sir Isaac Pitman and Sons, Ltd., Parker-street, W.C.2. Price 12s. 6d. net.

The Kingdom of the Camera. By T. Thorne Baker. London: G. Bell and Sons, Ltd., York House, Portugal-street, W.C.2. Price 7s. 6d. net.

Fencing and Other Safety Precautions for Power Presses. London: His Majesty's Stationery Office, Adastral House, Kingsway, W.C.2. Price 1s. 6d. net.

The "Practical Engineer" Mechanical Pocket Book and Diary for 1935. Edited by E. G. Beck, A.M. Inst. C.E. London: Oxford University Press, Amen House, Warwick-square, E.C.4. Price 2s. 6d. net.

SIXTY YEARS AGO.

HAD the Ericsson pneumatic torpedo described in our issue of December 25th, 1874, represented the limit of man's inventiveness in weapons of its type the history of the Great War, on the naval side at least, would certainly have been very different from what it was. Ideas in those days were running on the development of the "fish" torpedo as distinct from the device or arrangement to which the name "torpedo" had for a number of years been applied, namely an explosive charge towed or pushed at the end of a rod attached to the attacking vessel. The Ericsson torpedo consisted of a rectangular sectioned box 8ft. 6in. long, 30in. deep and 20in. wide, built of thin steel sheets. A tapering block was attached to the rear end to form the stern and carried two counter-running propellers. To the bow end of the box the explosive charge was affixed. The propellers were driven by a twin-cylinder oscillating compressed air engine. The air was supplied by the torpedo boat to which the torpedo remained connected during its run by a flexible hose pipe which it pulled out as it moved along. The air supply was also used to operate vertical and horizontal rudders attached to the box. The torpedo was designed to run at a depth of 7ft. to 12ft. beneath the surface. Its course towards its target was observed by watching a mast, terminating in a wooden ball, which projected from the deck of the box. The ball reached above the surface of the water and was painted sea green on the enemy's side and white on the observer's. The horizontal rudders were actuated automatically to preserve the depth at which the torpedo ran but the vertical rudder, so it seems to be implied, was controllable through the hose pipe by the observer who could thereby direct the torpedo with certainty towards its target. A curious detail was the fact that the engines were made of bronze and had boxwood bearings. The engine compartment was open to the sea and the engines operated completely immersed in the water. The idea behind this arrangement was that the water should serve as a lubricant to every moving part. Danger of the mechanism failing because of rust or from neglect to oil it was thereby avoided and in addition it became unnecessary to provide the propeller or rudder shafts with stuffing-boxes. The torpedo was launched by lowering it from davits swung out from the side of the attacking vessel. Trials in the United States had demonstrated, we reported, that the invention possessed a remarkable degree of efficiency. Its probable result on naval warfare could, we said, only be surmised. Captain Ericsson asserted that with a charge of 1200 lb. of guncotton his torpedo could break any ironclad completely in two. Armour plating even if it extended to the keel would not, we thought, be sufficient protection and even the "Inflexible's" one hundred and twenty water-tight compartments would probably not save her from destruction. Nevertheless we felt that the ingenuity which could devise so powerful a weapon of attack could equally well produce a satisfactory means of defence against it. For the moment, however, we could picture no means of defence save that of giving an enemy the widest possible berth and fighting at an enormously long range. . . . That, virtually, is still the only efficacious solution of the problem but it has been inspired not by the Ericsson torpedo but by the free type produced by Whitehead who, even at that date, was rapidly bringing his invention to the stage of practical success.

A New High-speed Centrifugal Fan Construction.

By ROBERT DOWSON, B.Sc., M. Inst. C.E.*

GENERAL REMARKS.

ORIGINALLY introduced for the pumping of liquids, the centrifugal impeller appears to have been first adapted for use with gases by Parsons in 1887* and by Rateau in 1899.† About the year 1905‡ Rateau introduced the multi-stage centrifugal type of blower or compressor, which has since been developed by so many steam turbine manufacturers.

Two main principles of design have been followed in order to attain the necessary high peripheral velocity of the impellers in a centrifugal compressor—essentially a high-speed machine. These are :—

(1) The use of materials of construction the strength of which is a maximum.

(2) The proportioning of the parts so that the stresses for a given peripheral speed are reduced to a minimum.

The Parsons type of machine, developed along these lines during the past twenty-eight years, commenced with the comparatively low peripheral speed of 525ft. per second, which was gradually increased to 744ft. per second by the year 1930.

This rise in peripheral speed represents, of course, an increase of stress of two to one in similar fans. It became permissible principally on account of the improved quality of the materials available.

The improvements in geometrical proportions, giving a stronger mechanical design, have been

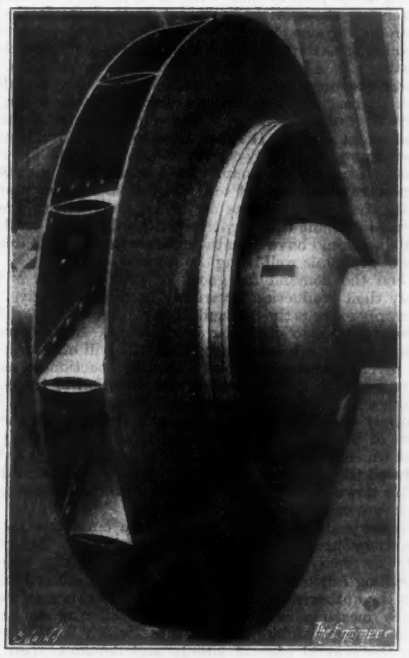

FIG. 1—CENTRIFUGAL IMPELLER

mainly empirical on account of the extreme difficulty of stress analysis in the peculiar construction of a centrifugal impeller, in which the fan cover plate is overhung entirely from the back plate and the centrifugal load on the vanes is shared between the two. Overspeed tests, carried out specially for the purpose of exhibiting weaknesses, show that the most common place of failure is in the vanes. The vanes begin to fail by bending between the fan plates, indicating the severe bending stresses which must exist.

Thick vanes, curved and profiled to a more or less stream-line shape, are, of course, more rigid than thin plates, but do not entirely solve the problem, on account of the difficulties of manufacture. The vanes must be as light as possible, preferably of the same material as the fan plates, and reasonable in cost—conditions not easy to reconcile with one another.

NEW DESIGN OF CENTRIFUGAL IMPELLER.

A new type of vane construction developed by Messrs. Parsons, which is inexpensive and extremely strong, lends itself to the use of sheet steel vanes, in which the principal stresses induced in service are readily calculable.

The construction is shown in Fig. 1. The fan plates, though tapered and reinforced at the hubs, form a parallel passageway and are not dished. It will be seen that the vanes are straight and of a hollow fish-shaped cross section. Their mechanical strength lies in this peculiar design. The expression for the radius of curvature ρ of a fan vane is§

$$\rho = \tfrac{1}{2}\left(\frac{r_o^2 - r_i^2}{r_o \cos \alpha_o - r_1 \cos \alpha_i}\right) \quad . \quad . \quad . \quad (1)$$

where r_i and r_o are the radii at inlet and outlet respectively and α_i and α_o are the angles with the tangent.

The condition for straight vanes is evidently that

$$r_o \cos \alpha_o - r_i \cos \alpha_i = \text{zero} \quad . \quad . \quad . \quad (2)$$

whence ρ becomes infinite. The most suitable values of α_i and α_o having been predetermined from experiment, the ratio $\frac{r_i}{r_o}$ for the fan vanes is the inverse ratio of the cosines of those angles. The product

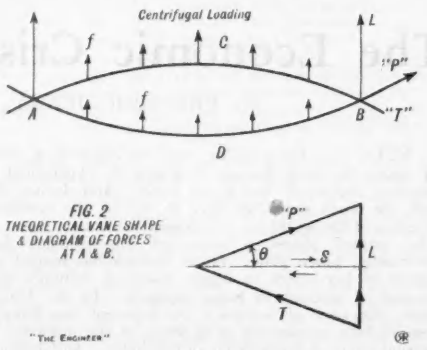

FIG. 2 THEORETICAL VANE SHAPE & DIAGRAM OF FORCES AT A & B.

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$r \cos \alpha$ at any radius is constant, and the component of centrifugal force on each element of vane, normal to the plane of the vane, is constant in magnitude throughout the entire length.

IDEAL GEOMETRICAL CONSTRUCTION OF FAN VANES.

The ideal curves for the contour of the fish-shaped cross section of the vanes would be catenaries. The centrifugal tension induced in the outer half vane (Fig. 2) is then practically equal to and balanced by the compression in the inner half vane, the bending moment being zero, there being left only a resultant shear at the lines of junction of the two halves. There is thus no tendency for the fan plates to be pulled together or pushed apart, and the loading they receive from the vanes is parallel to their planes, being carried by the attachment between the vanes and the plates.

The compression P or tension T at the edge of one half vane includes the components T sin θ and T cos θ.

With the halves of the vane united, $F = 2\,T \sin \theta$, becomes the load L on the supporting rivets (Fig. 1), while T cos θ is the shear S across the line of junction of the two halves.

Since for the complete vane (Fig. 3)

$$\frac{h}{a} = (\sec \theta - 1) \quad . \quad . \quad . \quad . \quad . \quad (3)$$

a large value of $\frac{h}{a}$ gives a small value to the ratio $\frac{T}{L}$ but at the same time makes a "humpy" vane. On the other hand, a small value of $\frac{h}{a}$ gives a flatter vane, but makes $\frac{T}{L}$ larger, and for practical purposes a choice has to be made intermediate between the two.

Thus if θ is arbitrarily chosen, then

$\frac{x}{a}$ is obtained from $\sec \theta = \cosh \frac{x}{a}$

while $$\frac{h}{a} = \cosh \frac{x}{a} - 1$$

and $\therefore$ $$\frac{h}{x} = \frac{h}{a} \cdot \frac{a}{x} = \frac{\text{rise}}{\text{semi-span}}$$

In a given fan the value of x will be determined

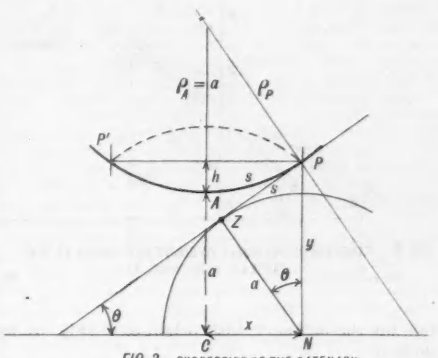

FIG. 3 PROPERTIES OF THE CATENARY.

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from the air calculations, so that the parameter "a" becomes known.

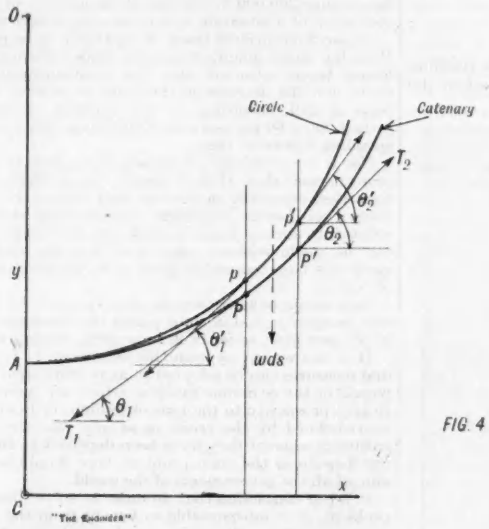
The contour of the vane has then to suit the equation

$$y = a \cosh \frac{x}{a}$$

PRACTICAL METHOD OF CONSTRUCTION.

Remembering, however, that the parameter "a" is also the radius of curvature at the vertex, a convenient method of making a vane suggests itself, namely, to use a circular arc of radius "a." Before the practicability of this suggestion can be decided, it will evidently be necessary to establish first whether the errors between a circular arc of radius "a" and the true catenary are permissible or not.

Due to these errors the bending will not be entirely eliminated, and there will be a residual bending moment which may induce stresses which are too great, so that the whole object of using the particular vane construction may be defeated. Considering, therefore, this matter of the errors between the circular arc and the catenary, the starting point is that in a true catenary-shaped structure (Fig. 4), $T_2 \sin \theta_2 - T_1 \sin \theta_1 = E\,H = w\,ds =$ the weight of the element $PP' = ds$. Considering a circular arc coinciding with the catenary at the vertex, it is evident that



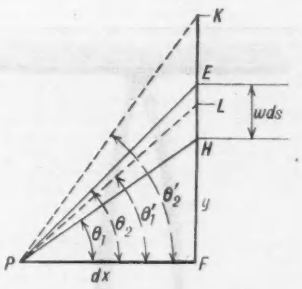


FIG. 4 COMPARISON BETWEEN CATENARY & CIRCLE.

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$$T_2' \sin \theta_2' - T_1' \sin \theta_1' = K\,L \gtrless w\,ds.$$

Thus, if in Fig. 4

$$E\,H = w\,ds = A,$$

and

$$K\,L = B,$$

then

$$\frac{B}{A} = \frac{K\,L}{E\,H} = \frac{(\tan \theta_2' - \tan \theta_1')/dx}{(\tan \theta_2 - \tan \theta_1)/dx} = \frac{\text{rate of change of slope of circle}}{\text{rate of change of slope of catenary}} \quad . \quad (4)$$

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* Research Department, C. A. Parsons and Company, Limited, Newcastle-on-Tyne.

* *Engineering*, Vol. 84, July, 1907, p. 2.

† *Ibid*, p. 30.

‡ *Ibid.*, p. 30.

§ "Single and Multi-stage Centrifugal Pumps," by Raymond Defeld, 1930 edn., p. 30.

For a circle with origin at the centre (Fig. 5) and equation

$$x_1^2+y_1^2=a^2,$$

the second derivative is

$$\ddot{y}=\frac{a^2}{y_1^3}$$

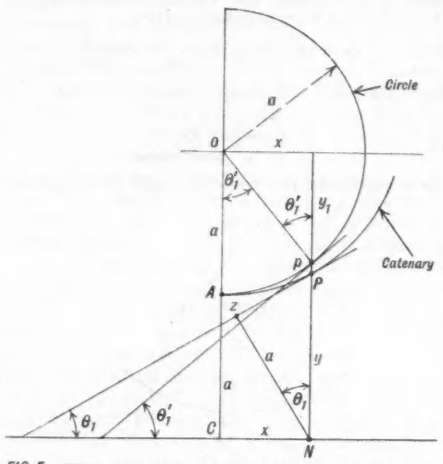

FIG. 5 TANGENTS RESPECTIVELY TO CIRCLE WITH ORIGIN AT O, & CATENARY WITH ORIGIN AT C.

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while for the catenary with origin at C (Fig. 5), and equation

$$y=a\cosh\frac{x}{a},$$

the second derivative is

$$\ddot{y}=\frac{1}{a}\cosh\frac{x}{a}=\frac{y}{a}$$

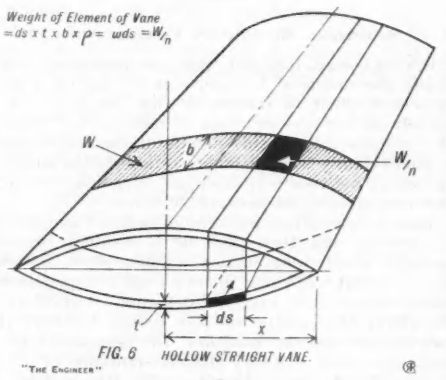

FIG. 6 HOLLOW STRAIGHT VANE.

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Hence equation (4) becomes

$$\frac{B}{A}=-\frac{a^2}{y_1^3}\cdot\frac{a^2}{y}=-\frac{a^4}{y_1^3\,y} \quad . \quad . \quad . \quad (5)$$

from which an estimate can be made of the residual bending moment in any given case. Thus, when the

FIG. 7—WELDED VANE

proportions of the vane are known, the arc A P (Fig. 5)

$$=Z\,P=a\,.\,\tan\theta_1$$

$$=a\,.\,\sin h\frac{x}{a}$$

and the weight W per inch length of one half vane is equal to

$$2\,Z\,P\,.\,t\,.\,\rho\ \text{lb.}$$

For practical purposes, the length of the catenary or arc is indistinguishable from that of the chord, so that, dividing the total span $2x$ into "n" elements (Fig. 6), the value of $w\,ds$ is with sufficient accuracy

$$\frac{W}{n}\ \text{lb. per inch length of vane.}$$

At an angular velocity of ω radians per second, this is magnified by

$$\frac{\omega^2 r}{12\,g}\,.\,\cos\alpha.$$

A table can then be drawn up giving the values of the error $\left(\frac{B}{A}-1\right)$ for all the elements of the vane span, and these values multiplied by

$$\frac{W}{n}\cdot\frac{\omega^2 r}{12\,g}\cos\alpha$$

give the residual unbalanced centrifugal force on each.

These residual values may then be set out as a force diagram and a vector polygon and link polygon of residual bending moment completed in the usual manner. The geometry of the cross section of the vane being assumed, by a well-known procedure the residual bending stresses are determined at every point along the vane span.

In this way suitable proportions for the fish-shaped cross section of the vane may be readily decided. The calculations of the total resultant centrifugal force on a vane, the stresses in the vane walls due to oblique resultant centrifugal force, and the shear stress in the rivets, present no difficulty.

EXPERIMENTAL VERIFICATION.

In an experimental 42in. diameter impeller with steel vanes, 4½in. wide, the latter were constructed by welding the two circular arcs together (Fig. 7). Each half vane was pressed to shape and the edges bent over to form a flange suitable for attaching the complete vane to the fan plates by means of rivets.

Speed trials of this fan have confirmed the correctness of the mechanical design. Incipient failure commenced in the vanes practically at the same speed as it occurred in the fan plates, and, as in addition, the latter were not subject to severe indirect stresses due to distortion of the vanes by bending, the safe speed of the fan was much increased.

The pressure volume characteristic of the fan and casing agreed closely with that predicted from a complete one-seventh scale model previously made and tested at 8000 r.p.m.

The Economic Crisis and the Way Out.*

By FREDERIC JENNY, Financial Editor of *Le Temps*.

A FULL year has gone by since we exposed, in these pages, the fond illusions to which the experiment of President Roosevelt had given birth. And during this year, we much regret to have to say it, the economic situation of the world has progressed but little.

In certain places a measured improvement has, admittedly, taken place. Great Britain has reaped the reward of her effort to regain financial stability in a renewal of activity in home markets. In the United States the pace of economic development has likewise been slightly accelerated as a result of the influence on internal prices of depreciation of the dollar. And over and above this, the shortage in the yield of crops in 1934 has produced a marked decrease in supplies carried forward from earlier years, with a consequent prospect of improvement in the agricultural position of the main producing countries, notably in South America. Nevertheless, in all this, so far, there is nothing really definitive, nothing to justify the conclusion that the world is actually overcoming the unprecedented difficulties with which it has been face to face for five years.

The number of unemployed is still nearly ten millions in the United States. In Germany it has ostensibly been reduced from over four millions which it had reached early in 1933 to about two and a-half millions now, but this result has largely been achieved either by artificial means or by a modification in the form of compiling statistics, so that it is far from reflecting any genuine improvement. And even in Great Britain, where the improvement has been more marked than anywhere else, there are still more than two million workers without regular employment—a figure some 300,000 below that of the autumn of 1933, yet indicative of a situation which remains clearly abnormal.

As for international trade, it continues to be paralysed. With but slight qualifications, the trade returns are at the lowest levels recorded since the commencement of the crisis, and the decrease in the value of exports on a gold basis is still, according to the different countries concerned, from 60 per cent. to 70 per cent. below the corresponding figures of 1929.

Nor is the circulation of money at the present time any more normal than that of goods. In a whole crowd of countries, especially in Eastern and Central Europe, the control of foreign exchange is becoming stricter and stricter, to such a degree indeed that no foreign payment can be made without restriction and the exchange of goods has been reduced in practice to the barbaric system of barter.

To sum up, nowhere can we observe signs of a rebirth of real prosperity, and in some places the economic situation in the past year, so far from improving, has got worse.

How can we escape from this depression? What remedial measures can be adopted so as to start once again the wheels of the economic machine which are jammed, so as to give prosperity to the tens of millions of human beings overwhelmed by the crisis, or at any rate the means of existence whereof they have been deprived? Here, without dispute, is the main problem, here should be the first aim, of all the governments of the world.

It is our conviction that, in order to solve this stubborn problem, it is indispensable to benefit from the lessons of past experience. Objection may be made that the statesmen who now preside over the destinies of the peoples should have the forward glance rather than be absorbed in retrospect, that what it behoves them to attempt is bold innovation, and that the highway to prosperity to-day cannot be the same as in the crises of the nineteenth century, when the difficulties to be overcome were immeasurably smaller. And yet the phenomena which we note at the present time are precisely those which were observed in earlier depressions. The only difference is one of degree. The depression is now much more accentuated than ever before and, precisely on this account, the economic difficulties have been complicated by a monetary chaos which aggravates them and prolongs their duration. Such being the case, why, in the name of reason, should the means which proved victorious over earlier crises be impotent to get the better of our present disorders and to overmaster the prevailing crisis?

There is after all nothing incomprehensible or mysterious in an economic crisis, even in that which we are experiencing at the present time. We are in the midst of simple phenomena, whose origin lies mainly in the imperfection of human intelligence.

Economic activity exists in a condition of perpetual evolution; it is incompatible with stable equilibrium, its evolution is comparable with the movement of a pendulum which alternately passes, in one direction or the other, its centre of gravity. And why this continual movement of advance and recoil? It is because the precise and lasting adjustment of the supply of products, so as to coincide with the actual needs of humanity, is a task which surpasses the powers of the wisest and most clear-sighted minds. If only the guiding spirits of the larger countries would take into account this negative but fundamental truth, a great step would have been taken towards the re-establishment of economic well-being the world over.

When the demand for goods or produce exceeds the supply then production invariably becomes excessive. If the supply exceeds the demand, then production invariably becomes more restricted than is necessary. Nothing but a natural law, which is stronger than the will of men, can, at a given moment, provoke a healthy reaction so as to create a contrary movement in the direction of the equilibrium which has been disturbed. Now, this natural law of supply and demand enforces itself through the mechanism of prices. It is the reversing of the tendency of prices which normally indicates to the producer that he has produced too slowly or too rapidly, that he must speed up or slow down, or that he must introduce modifications in the nature or the quality of his goods.

We are somewhat ashamed to have emphasised such elementary matters here, and we apologise. But it is really necessary to bear steadily in mind the natural controlling function of prices in order to appreciate that, when the authorities of the State take upon themselves to enforce measures with the object of altering or fixing prices at levels different from those which would result from the normal play of supply and demand, then the natural law is interfered with, and the producer is led into error, and equilibrium is no longer possible.

The need of allowing prices to act as a warning signal, as a barometer, should also logically exclude the manipulation of the currency as a means of overcoming economic depression. If prices find their level not according to a fixed criterion of value, but according to a medium which varies with the wishes of men, then they are indicative of nothing. All they can be in such circumstances—and that only by the extent to which the desired result is achieved, which is by no means always—is a reflection of the wishes of the government concerned, but in no sense a true revelation of supply and demand. And here, again, the producer, deprived of the only reliable guidance which was vouchsafed to him in the past, is led astray. Walking blindfold, he is exposed to dangerous pitfalls.

When we insist upon the necessity of giving full play to the fundamental and natural law of supply and demand, we by no means shut our eyes to progress; to affirm this would be to assert the reverse of the truth. The swing of the pendulum which has characterised economic activity for over a century has not impeded a rapid forward movement. Whenever, after periodical disturbances, equilibrium has been re-established it has always been so at a relatively higher level. Producers on each occasion have been enabled to market a larger total volume of produce and humanity has enjoyed a level of prosperity invariably greater than before.

In point of fact, lack of co-ordination between production and consumption never arises from an excess in production in the aggregate, no matter whether the apparent cause be over-production or under-consumption, both these phenomena being usually concurrent and interlocked. Basing themselves upon the needs or the preferences of consumers as indicated during a given period, agriculturalists and industrialists guide their efforts in accordance with the directions thus indicated, and it is precisely in these very directions that, with the approach of a crisis, supply most exceeds demand. Progress in the development of machinery has greatly aggravated

* From *Lloyds Bank, Ltd, Monthly Review*, December, 1934.

such excessive production, and it is very curious to observe what strange illusions producers can labour under as to national or universal capacity of absorption, in respect of any particular commodity, when once the upward movement of consumption has, in the natural course, been reversed. A case very much in point is that of the motor industry, especially in the United States, during the years 1926–29.

Thus a crisis does not necessarily reveal to producers that they have produced too much in general. Rather does it show that they have produced too much of a certain category of goods; in other words, that the direction of their production has not been modified sufficiently soon. And it is not difficult to appreciate what an indispensable, and, indeed, what a really governing, function the price level plays in this respect.

Similarly, it will be apparent that if governmental authorities intervene to prevent prices from falling when the supply exceeds the demand, they thereby implicitly encourage producers to persist in the false direction they have already taken, and thus the authorities postpone the re-establishment of equilibrium. The experience we have had in regard to cereals is an eloquent demonstration of the crass error involved in such a procedure. First of all in the United States, and then in France and in other countries, the authorities desired to maintain the price of corn at a level which did not correspond to that of supply and demand. Result: instead of producing more of other commodities and less corn, farmers, unwisely encouraged by the State, continued to produce more corn than it was possible to sell, and the agricultural crisis became chronic. And if now we can, in respect of agriculture, hope for some early relief this is due to a natural force, superior to that of man, manifesting itself in the shape of unfavourable weather, which has thus fortunately come to the assistance of impotent and misguided governments.

Speaking generally, the co-ordination of supply and demand is a task at once complicated and delicate, and only men of business, industrialists and farmers themselves can perform it, owing to their expert knowledge and qualifications and their constant contact with markets. The task involves efforts carried out from day to day and of infinite diversity, and it can only be duly appreciated in all its complexity and ramifications by men of commercial ingenuity with the spirit of business initiative. The necessary efforts can in actual practice only be accomplished under the pressure of necessity—that is to say, under the commercial menace that undertakings which do not adapt themselves to the wishes, the needs, and the purchasing powers of the public are bound to go under and disappear altogether.

In substance, this state of affairs is simply one aspect of the hard struggle for existence. Those governments which, by artificial intervention, wish to render the struggle of producers easier are assuredly animated by the best intentions. But they are on a false scent, inasmuch as it was precisely the severity of the struggle which proved a *sine qua non* of the gigantic progress achieved in the economic field since the beginning of the nineteenth century. Why should the producer, once he feels that the State is ready to support him and save him from ruin, bother himself any more with the irksome search after what is necessary or agreeable to the consumer? Why should he seek constantly the means of reducing the net cost of production and of sale and thereby increase the purchasing power of the public? All he has to do is to rely upon government departments, who protect him and, more or less, assume the responsibility of the success or failure of his undertaking. Since government departments are neither omnipotent, nor omniscient to the extent requisite to replace the tenacious efforts of all those who have hitherto collaborated, with knowledge sharpened by the daily struggle for existence, in the business of the world, all progress is impeded by State intervention of the nature described and the lack of equilibrium in affairs becomes chronic.

In bearing these general truths in mind we shall be able to diagnose the causes both of the severity and of the exceptional duration of the prevailing crisis.

First of all we must go back to the war of 1914–1918, which is the basis of our present difficulties. For more than four years the whole world manufactured articles destined either to destroy or to be destroyed. Such activity as was not actually devoted to this unprecedented work of demolition was, for the most part, applied to revictualling the fighting forces, and did not arise from any normal economic need. Thus, it came about that for more than four years producers did not have to worry at all about their markets, nor about the needs of consumers, nor even about the net cost of production.

When hostilities came to an end it was necessary to rebuild what had been destroyed, to replenish exhausted stocks and to make good what had been neglected during the war. That is to say that, so far as producers were concerned, the era of easy-going conditions continued. All goods found a ready purchaser, prices were agreed almost without discussion, all that was necessary in order to sell was to produce.

With the advantage of such unlimited scope—which was never curtailed except for a short period owing to the crisis of 1921—industry advanced with giant strides, aided by the technical progress in methods achieved during the war. Factories were multiplied in industrial countries, where the aim in view was not merely to make good shortages due to the war, but also to manifold means of production which were deemed inadequate. And even in those countries which but lately had been purely agricultural, factories arose like mushrooms, in order to take advantage of easy conditions and to produce at home what had previously been imported from abroad.

When the first symptoms appeared of an early reversal of prevailing conditions, those who presided over the destinies of most of the countries of the world never for a moment had an idea that it was incumbent upon them to warn producers of the dangers which threatened them and to urge a measure of prudence. On the contrary, and incredible as it may seem, their one preoccupation was to induce all concerned to close their eyes to warning signals and to persist in the illusion of a wellbeing which was fallacious. With this aim in view credit was abused, and facilities were almost shovelled out to manufacturers and farmers, who were thus induced to increase their commitments, whether in the form of investments or production; indeed, in certain countries large credits were given to consumers, who were thus induced to mortgage their future and to forestall their power to make future purchases.

The upshot of all this was that the swing of the pendulum, to which we alluded above, was far greater than ever before; that producers, thanks to the prolonged period of easy-going conditions, lost the faculty of adapting their activity to the normal play of supply and demand; and that, when once the crisis actually did break out, the disturbance of equilibrium was infinitely more severe, and the shock far more abrupt, than in any previous crisis of history.

And in the midst of this catastrophe, public authorities, misguided in their conceptions of policy, acted clean contrary to the real interests of world prosperity, and, by so doing, to the true interests of particular countries whose prosperity they were concerned to protect and defend. Seeking to check the fall in prices by a multitude of artificial controls, protecting national producers by impassable barriers against foreign competition, they have merely held up and delayed that readaptation which is indispensable. Furthermore, they have given rise to a narrow system of nationalist economies which has led to that disastrous withering of international trade that we have witnessed during recent years. By so doing they have simply dried up an important number of outlets for their own national products. This policy, instead of overmastering the crisis, has rendered it far worse than it need have been.

Turning now to the abuses of credit whereby it was sought first to speed up production and then to put off the hour of inevitable collapse, these abuses are directly responsible for the monetary difficulties which have been superimposed on the economic difficulties properly so-called, and they have created the distinctive features which characterise the present crisis. Indeed, abuses of credit have been destructive of confidence in the world, whereof no less than four-fifths are completely deprived of any stable means of exchange; they have added a further obstacle to international trade, inasmuch as the lack of a stable currency makes international contracts difficult. Besides, they have made it necessary for certain countries to control severely the export of capital. This has rendered it impossible for those under their jurisdiction to settle their foreign debts or to pay for purchases from abroad in the normal manner, and the result has been the establishment of clearings or other makeshift arrangements which, in the long run, merely hamper international commerce still further.

Here, in a nutshell, is why the prevailing depression has been deeper, more prolonged, and more widespread than earlier ones. Producers, as a result of the war and its consequences, formed bad habits, and these bad habits —which largely arose from abnormal facilities wrongly diagnosed as indicative of enduring prosperity—were actually encouraged instead of being corrected by the systematic interference of public authorities, both political and financial, in matters of business.

What is to be done to regain prosperity? The question is a difficult one, precisely because the swing of the pendulum has carried us much farther from the centre of gravity than in earlier depressions and the damage caused by the present crisis is accordingly far more widespread and severe. Nevertheless, without the risk of going astray, we may fix a certain number of points which we consider every person with an objective outlook will admit to be incontestable.

The first point is that the remedy for the crisis cannot be found in the adoption of State control, or, what amounts more or less to the same thing, in the introduction of Socialism.

Certain people, and those not the least prominent, have sought to establish that the prevailing crisis indicated the failure, the final condemnation, of capitalism; that capitalism had been shown to be out of date, and that a new era was about to dawn. In our judgment those who reason thus have no clear conception of the real nature of capitalism, whilst we deem that the crisis which is now afflicting the world, so far from constituting the condemnation of capitalism, is in point of fact its justification.

What exactly is capitalism? In substance it is a system of *liberty*, a system whereby each individual is enabled, within the limits fixed by governments in order to ensure public order and the rights of others, to seek and to obtain his own personal advantage and profit, and to dispose of or to conserve that profit as best may seem to him. It is a system which presupposes for each individual the possibility of exercising freely his initiative in the economic sphere. It presupposes, further that each individual should be able to defend himself freely by means of competition; that the rights of property should always be strictly respected, and that commercial undertakings, making the best use of accumulated reserves, should alone carry the risks involved.

Thus defined, the capitalistic system can only function normally provided the State abstains from interference with fixing of prices, from warping the play of demand and supply, and from checking competition. The day when governmental authorities take upon themselves to fix minimum wages, to retrict the hours of work, to limit sale prices, and establish quotas for different manufactures or for produce, such as has recently been done, for example, in America; the day when they decide upon an expansion of credit over and above the prudent limits which experience leads bankers to observe; the day when they arrogate the right of controlling currency, credit, and trade in general, and when, over and above this, they destroy private property by levying oppressive taxation—when that day comes, we are no longer living under a capitalistic system, but under the shadow of a policy which is already largely socialistic. Now what the prevailing crisis exposes and condemns is precisely this socialistic policy, and not capitalism. If capitalism were left to itself, if it were liberated from the baneful influences which governmental authorities have exercised upon it, then assuredly it would never have committed abuses comparable to those which have brought the world to the sorry pass where it is to-day.

Experience proves incontestably that the further the brain which directs a business undertaking is removed from the market centre of that particular undertaking, the greater are the risks of error in the conduct of the business. In the period which immediately preceded the crisis it was in the largest undertakings, constituted by the amalgamation of a number of separate and independent units, that the most disastrous experiences were recorded. Can it be doubted that if we had a complete system of State control, with the governmental authorities claiming to direct the economic activity of a whole country, the risks of going astray would be as great as it would be possible to make them? Sooner or later the statesmen responsible for the destiny of the nations must surely recognise that neither their genius nor their capacity are such that they can ever satisfactorily replace the collective intelligence of producers in general, who, in their daily struggle for markets, are face to face with realities.

Those who wish to do a good work should seek, then, to strengthen and not to weaken capitalism. It is indispensable to free it from the impediments which have checked or misdirected its action in recent years, for it is undoubtedly these impediments—the same which have hampered the play of supply and demand—which are very largely responsible, if not for the crisis itself, at any rate for its severity and duration.

The second point which we should regard as definitely established—and which, moreover, is closely connected with the first—is that the policy of a steady rise in prices is contrary to the result to be desired. Such a policy is based upon a profound misapprehension, to wit, that the crisis in general, and especially the monetary crisis, is due to a catastrophic fall in prices. In reality the fall in prices is an effect of the crisis and not its cause. And when once the depression has been overcome and we look back at it we shall probably remark that it was not the fall in prices, but their previous rise, provoked by speculation injudiciously fanned by the inflation of credit, which was the most catastrophic feature of all.

A policy which aims at a rise in prices by artificial means should be rejected *a priori* because it is an integral part of that State-controlled system or manipulated economy which experience has demonstrated to be erroneous. If the world is ever to regain reasonable stability, prices must be determined by supply and demand, and must not be arbitrarily manipulated. Moreover, it is neither certain, nor indeed probable, that stability can be achieved at all with prices at a notably higher level. Machinery has made prodigious progress in the last twenty years. This progress, which, after all, can never be undone, inasmuch as it would be contrary to the nature of things to attempt it, should normally express itself in a general lowering of the level of prices, a lowering which is *possible* owing to a reduction in the costs of production, and *necessary* because it is the only way whereby the great body of consumers can absorb the increased quantity of goods which improved methods have made it possible to produce. Thus it was that the first crises were overcome which arose owing to the introduction of machinery and the displacement of labour; when they arose these crises seemed just as difficult to overcome as the prevailing crisis, but they were, in fact, overcome, and did not prevent progress from following. As to those raw materials whereof the sale value may have fallen below the cost of production, prices will adjust themselves to supply and demand so soon as the less efficient producers have fallen out. Besides this, it is quite possible that the general evolution of conditions may necessitate a further effort to reduce the costs of such raw materials.

From the moment that we consider as anti-economic any policy which aims at a rise in prices regardless of conditions in general, we are likewise compelled to consider in the same light any systematic expansion of credit, since indirectly it has the same object as a rise in prices. The flow of credit should not seek to lead and direct economic development, it should rather follow such a development, adapting itself to the normal requirements of industry and commerce in so far as they are efficiently conducted. Otherwise credit results either in the freezing of liquid assets, which played such a harmful *rôle* in the international financial crisis in 1931, or in the constitution of those great masses of floating capital whose movements, as we witnessed in the case of sterling three years ago, may become a truly formidable danger even for the soundest currencies.

The blind inflation of credit in order to give an impetus to business is a form of that controlled economy which is diametrically opposed to capitalism, although certain individuals, most unjustly, have sought to render capitalism responsible for it. Economic activity is healthy when consumption is on the increase. This being so, normally bank loans should facilitate production rather than purchases by consumers; in the latter contingency loans are inflation of credit and usually, if not always, unsound. It is for this reason that the expansion of credit defeats itself, and even augments the existing lack of stability, if it is not instigated by definite indications that economic recovery is already taking place.

And now we pass to the third point, which is absolutely essential; to overcome the world depression it is indispensable to develop free trade.

Since there exists a profound disparity between production and consumption, and since the restriction of output can never be more than a temporary expedient—and even then an expedient contrary to natural evolution and therefore opposed to progress—sooner or later we must seek a remedy in an increase of the total volume of sales. But such an increase can never attain the requisite level if the only outlet for producers is limited to their home markets. In order to allow humanity to draw from industrial progress the advantages which it can and should afford; in order to prevent that progress (which can and should constitute a boon for humanity) from becoming a calamity, it is necessary that division of labour should be restored amongst nations, in the same manner as it exists amongst individuals. It is necessary that each nation should produce, and be enabled to sell to others, that which it is best fitted to produce. In a word, it is necessary that such a re-adaptation of world products to world needs should take place as can only be promoted by the most free and most extensive system of competition possible to conceive. And world needs can only be stimulated and developed by low prices and by the offer of fresh and attractive goods and commodities.

We shall no doubt be told that we are merely banging on the old drum, that there is nothing new in what we say, that all we are doing is to enunciate the old principles of liberal economists. We gladly plead guilty to this charge. The logic of events compels us to recognise that under the

old system men were happier and the world was far more prosperous than now ; that, after all has been said, the old system overcame difficulties as great, if relative conditions be taken into consideration, as those which now afflict us, whilst the nostrums in favour recently, whether they be dubbed State control, socialism, or managed economy, have one and all resulted in miscalculation and bitter disappointment. Such being the case, it seems to us far preferable to follow modestly a system which has proved itself in practice, rather than to adopt high-flown theoretical systems which, by ways more or. less indirect, invariably end in interference by the State with the freedom of affairs and, consequently, in the paralysis of healthy business activity.

Once we admit the need of restoring international trade we are driven in the first place to claim the lowering, so far as may be, of existing obstacles to free trade, such as prohibitive customs duties, quotas, and other barriers which are more or less insurmountable. It is crystal clear that, so long as these obstacles remain, the embarrassments which afflict the world will continue. It is not in seeking to be self-sufficient, and in existing merely by restricting their own requirements, that the nations of the world will regain prosperity. If this state of affairs goes on it implies a continuance of depression and unemployment.

But yet another impediment must be thrown aside if free trade is to blossom once more. That obstacle is monetary instability.

We are far from blind to the fact that, when we proclaim the need of linking up the principal currencies to gold, we are not at one with the dominant view in Great Britain which, in the meantime, continues to prefer the paper pound to the gold pound. This dominant view is no doubt to be explained by the improvement which has been noted in the economic situation of Great Britain. Why, it is asked, should we modify our monetary system, since that which actually exists has been accompanied by economic recovery ?

This opinion is easy to understand, but, we repeat, it does not convince us. In the first place, it is far from being clear that there exists a relation of cause and effect between the abandonment of the gold standard and the improvement in the economic condition of the country. That improvement is manifestly due to the clean up of the public finances in 1931–1932, to the conversion operations thus rendered possible, and to the resultant fall in interest rates both for long and short-term loans, and above all to the restoration of confidence at home which is the fruit of a prudent financial policy. It has no relation whatsoever to depreciation of the currency. If in reality the monetary factor had exercised a dominating influence the recovery would have manifested itself especially in the volume of exports. Now during the first nine months of 1934 British exports only attained a value of £289 millions, against £292 millions during the corresponding period of 1931, that is to say, an amount nominally slightly inferior to that recorded during the nine months which immediately preceded the suspension of the gold standard. Accordingly, the yield of British exports to-day, calculated in pounds which are depreciated 40 per cent. in value by comparison with the gold pound, is not as high as it was at a period when the crisis was in full swing. Surely this is not a feat to write home about !

It is an incontestable fact that the instability of currencies is an impediment to international trade. It clogs trade first of all because it creates mistrust in other countries, which are unwilling to allow their markets to be flooded by goods artificially cheapened by currency manipulations, and so they seek to protect themselves against such unfair methods of competition by Customs duties, which are ever on the up grade ; the interest of the whole world calls, on the other hand, as we have urged, for a lowering of such duties. Moreover, instability of the currency paralyses free trade because it is incompatible with the existence of mutual confidence and with a feeling of future security, and thus it renders impossible the conclusion of normal commercial contracts. How can it be otherwise when the seller of commodities does not know what real amount he will receive at the time of payment, and the purchaser is ignorant of the actual sum he will have to pay ? Let us abandon all hope of a recovery in international trade so long as these conditions persist, and therewith any hope of seeing a real and marked improvement in the general well-being. Local and partial improvements may be possible, but even they are likely to be of passing duration. In regard to Great Britain in particular, we shall doubtless not be contradicted when we affirm that that country, in view of its special economic position and its dependence on international markets, cannot count upon any lasting prosperity when its foreign trade is reduced as at present.

And it would be rash to imagine that the system of a paper currency will never entail, even in Great Britain, the disadvantages that it has provoked elsewhere, such as a rise in internal prices and in wages, inflation, and so forth. Amidst the prevailing international monetary chaos the pound sterling has a sufficiently strong position, thanks to its widespread circulation and radius of operation, to attract, even if dissevered from gold, foreign capital. But so soon as order begins to assert itself again on the monetary chessboard of the world the position of sterling will be rudely shaken. We saw a proof of this in the fact that, when once political anxiety due to the internal situation in France last winter had been calmed, and when the dollar had been provisionally linked up with gold again, the pound sterling was subjected to such a pressure for several months as impelled the central authorities to defend it by the sacrifice of gold in considerable quantities. Seasonal conditions alone would not suffice to explain this pressure, which can only be attributed to the fact that any paper currency is ultimately regarded with disfavour, no matter what its intrinsic prestige, so soon as it is in competition with stable and healthy currencies. And if this disfavour was less marked from the beginning of last October, the operative reason was certainly not the lessening of seasonal requirements, but much more political developments on the Continent, which gave rise to apprehensions in this direction.

Gold is perhaps not a perfect basis for money. Nevertheless, up to now human ingenuity has discovered nothing which can so well ensure the security of exchanges and contracts, nothing so well calculated to conserve wealth nothing which so well guarantees the currency against the arbitrary intervention of politicians, and so perfectly maintains public confidence. This is the reason why any return to a system or even modified liberalism in trade, such as will neither dominate nor act in opposition to natural forces (which guide economic development a thousand-fold better than the nostrums of governments) necessarily involves a general return to a gold basis as a common standard of value and as the basis of the principal mediums, such as sterling, of foreign trade.

No doubt a return to the gold standard will not of itself suffice to bring about a return of prosperity. But it can nevertheless, under present conditions, effect a marked change of direction—a psychological change due to the restoration of confidence, and a material change due to the possibility it will open up of a gradual restoration of free trade. And, what is a matter of the first importance, it is one of the few constructive means of recovery which the governments can set in motion, whereas in many other directions prudence may counsel a negative attitude and inaction.

To sum up, the restoration of economic well-being and stability seems impossible unless those who preside over the destinies of the nations will abandon the chimeras of State control, and will give free play, so far as possible, to the healing forces of Nature. To do this, they must make it their first and cardinal aim to place their respective countries in such a position, both as regards the currency and the granting of customs facilities, that the action of fundamental economic laws—which are two-fold, namely, the law of supply and demand and the law of division of labour—may be alike effective and conciliatory. Thus will follow a real advance towards the free and unrestricted development of the countless productive energies of the universe. Contrast this with the socialistic tendencies of State control, which only envisages interference, regulations, and cramping restrictions. Along this wrong road equilibrium can only be reached, if at all, by means of a disastrous and all-round setback in prosperity.

The main difficulty lies in weathering the dangerous cape to which liquidation of the crisis may be compared. This liquidation will prove the more painful because mistakes made up to the present have been very serious, and have had the effect of making the depression far deeper than it would otherwise have been. By their various measures of protection and artificial encouragement, governments have simply postponed the inevitable liquidation and thereby prolonged and intensified the crisis. Yet if all these misguided measures were abolished by a stroke of the pen, the liquidation would be so abrupt, so many undertakings would founder, that social disturbances might ensue and they would retard rather than accelerate a recovery. We should then have to cope with difficulties even graver than those which already exist.

Thus, while the end in view must be quite clear, in practice it will no doubt be necessary, owing to mistakes made in the past, to act with a certain measure of precaution. The change must be gradual, but it must be progressive, and in the right direction. If provisional measures have to be enforced during the transition period, in order, for example, to support weak borrowers, it is of the utmost importance that they should be treated as strictly transitional, and that they should not acquire the character of permanent institutions They should be regarded as measures which are in the strict sense of the word exceptional—measures which are solely intended to facilitate the change over to sound methods. Of one thing we may rest assured : those countries which abandon artificial supports most readily will be the earliest to overcome the crisis.

We fear we may have disappointed those who hoped we would lay before them a ready-made, artificial scheme of recovery. Let us be frank and open—it does not exist. We must allow Nature free play, and, in view of past errors, we must return to a state of free trade, gradually, it is true, but with ever-increasing velocity. Our change-over must, indeed, only be retarded to the extent absolutely necessary to avoid grave social upheavals.

One word in conclusion. The healing measures which we have advocated can only prove efficacious if the spirit of peace gains the upper hand in all the great countries of the world. But the trade policy for which we plead with all the emphasis at our command will promote the ends of peace, whereas the present trend towards economic nationalism is bound to end in exasperation, and cannot fail to endanger peace.

Economic nationalism rests upon the stupendous fallacy that man's neighbour is his enemy. In the long run, instead of creating work, it confuses effort ; instead of reducing unemployment, it paralyses progress ; instead of stimulating recovery, it deepens depression at home and abroad.

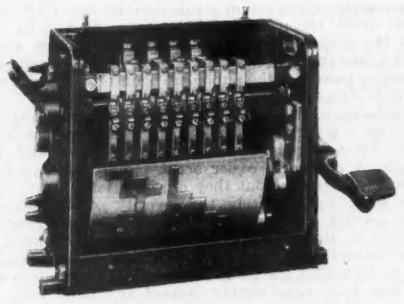
Trolly Omnibuses for Durban.

A FLEET of eleven four-wheel double-deck trollybuses has been shipped to Natal for use on the Durban Municipal tramway system. The chassis were built by Leyland Motors, Ltd., while the electrical equipment was manufactured at the Witton works of the General Electric Company, Ltd. Each vehicle is equipped with a single series-wound field-controlled 500-volt motor, shown in the first illustration, rated at 80 h.p. on the one-hour basis. By making the maximum amount of use of field control, the motors work with minimum power consumption, and hum is said to have been eliminated throughout the entire range of speed. High permeability fabricated steel forms the box frame, which is consequently light and compact. There are four adjustable brush holders, each containing one brush, and access to the brush gear is provided through large detachable covers at the top and bottom of the motor. The windings are cooled by a "parallel flow" fan, mounted on the armature, which runs in roller anti-friction type bearings lubricated by high melting point grease. As the motor is mounted towards the end of the chassis, the use of a short propeller shaft is permissible, and ample room is left for the auxiliary control gear on the chassis frame.

The control gear consists of a foot-operated master controller shown in the second illustration for actuating a bank of electro-magnetic contactors shown in the third picture. These control the connections to the driving motor, and the master controller only carries the currents required to actuate the contactors, so that it cannot be damaged even by improper use. The whole system is simple, and no interlocks are necessary. When the pedal is operated, the appropriate contactors first cut out the resistances step by step until the motor is connected directly across the line, and finally weaken the series field by shunting it with resistances until the final speed is reached. The controller also contains a reversing

TROLLYBUS MOTOR

drum. On the master drum, which is carried on ball bearings, there are adjustable spring fingers, with renewable contacts, the reversing drum being below the main drum, and as the two drums are interlocked the pedal must be in the "off" position before the reversing drum can be operated. The reverse handle can be applied at either end of the master controller, according to which is the more convenient. The accelerating and series field weakening contactors are of the same type and similar to those which have proved successful on electric railways. They are closed by vertically mounted solenoids and opened by gravity supplemented by springs. A "toe" and "heel" movement is given to the contacts, resulting

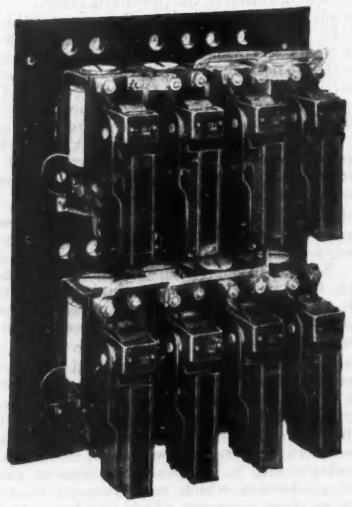


MASTER CONTROLLER

in a wiping action to ensure positive contact and long life. The arc chutes are fitted with strong magnetic blow-outs.

The contactors with the bakelite panel on which they are mounted, as shown in the third illustration, are enclosed in a wooden case, which precludes the possibility of any noise due to their operation reaching the passengers. Unbreakable jointless and rustless main resistances are mounted towards the front of the chassis. They are double insulated, and rated so that during foggy weather the vehicle can be driven at low speeds for considerable distances without overheating.

There is an automatic overload circuit breaker on each



CONTACTORS

pole, with contactor type mechanism and powerful magnetic blow-outs. The trip setting may be adjusted over a wide range, and the motors and power circuits are fully protected under all overload and emergency conditions. In addition to the circuit breakers, each circuit is double fuse protected.

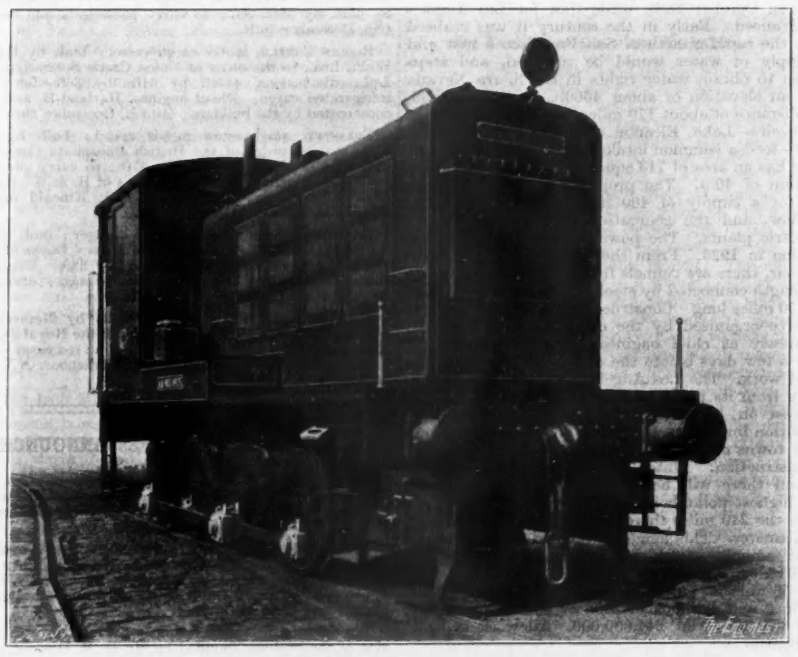
The trolly consists of two lightweight low type Brecknell Willis trollybases, designed for railless traction, and having Timken taper roller bearings and Tecalemit lubricators. Each base is fitted with an insulated tapered trolly pole made from heavy rolled weldless steel tube, and carrying a trolly head complete with wheel and safety cord. For running on ordinary tramway routes on

which the second overhead wire is not available, a skate is provided on the undercarriage, and a simple form of skate change-over switch operated by the reverser key of the controller prevents the power circuit being broken, while current is flowing through the motor.

The exhauster for the power brake is directly driven by a totally enclosed motor, which is arranged for automatic switching direct on to the line. To prevent wireless interference, stopper coils contained in insulated light aluminium are mounted on the roof of the vehicle. An indicator for detecting any leakage of current to the metalwork is fitted, and a power indicator consisting of a neon lamp is provided in the driver's cab to show when the trollies have been placed in contact with the overhead wires.

Oil Locomotive for the Air Ministry.

THE oil engine driven geared locomotive illustrated has recently been supplied by R. and W. Hawthorn, Leslie and Co., Ltd., of Newcastle, to the Works and Buildings Branch of the Air Ministry for service at the Cranwell depôt. In addition to carrying out shunting operations, this locomotive is required for the haulage of stores over the branch line system, involving runs of over 6 miles. It is of 4ft. 8½in. gauge. The locomotive has been built to the specifications and requirements of the engineers of the department concerned. The primary power is supplied by a six-cylinder, four-stroke, solid-injection heavy oil engine, supplied by William Beardmore and Co., Ltd., and develops 200 b.h.p. at 1100 r.p.m. as a normal working load. The cylinders are 6½in. bore by 9in. stroke. The engine is started by compressed air from a storage bottle carried in the engine casing. This storage bottle is filled by a Hamworthy petrol-paraffin direct-coupled air compressor placed in the locomotive cab.



200 B.H.P. OIL LOCOMOTIVE FOR THE AIR MINISTRY

To meet the severe shunting conditions, a friction clutch was not considered suitable for taking up the drive from the engine because such a unit requires careful attention under the best of conditions to enable the locomotive to start up heavy trains quickly and smoothly. In order to ensure that the drive would be taken up in a satisfactory manner, a Vulcan Sinclair automatic traction type hydraulic coupling, supplied by the Hydraulic Coupling and Engineering Company, Ltd., is bolted to the engine fly-wheel. An air-operated internal expanding rocking brake of sufficient power to stall the runner of the hydraulic coupling when the engine is idling is fitted to the runner shaft. This brake is connected to the speed change gear and comes into operation automatically when starting or changing gear, or it can be operated independently if required. Two Hardy Spicer discs carried in steel spiders are interposed between the rocking brake and the gear-box. The Hawthorn-Leslie constant mesh gear-box provides three speeds in each direction of 4·7, 8·4, and 15 m.p.h. Humfrey Sandberg free-wheel type clutches are fitted to three of the speed change wheels to provide the drive for each of the speeds. These clutches are air operated by operating gear carried in a control box attached to the gear-box. The reverse gear which is housed in a separate part of the gear case is of the spiral bevel type, with an air-operated dog clutch as the driving member and the final drive to the jack shaft is by spur gearing. The drive to the wheels from the jack shaft is by connecting and coupling-rods.

The frames and running gear follow usual locomotive practice and the engine is carried in a heavy built-up cradle frame built into the main frame. All the gears can be removed without lifting the gear case out of the frames. A belt-driven two-cylinder Reavell air compressor supplies the air for the brake and control equipments. Suitable valves and connections are fitted to the brake air receivers to enable the Hamworthy air-starting compressor to be used in case of emergency. All driving controls are duplicated at each side of the cab. To meet the climatic conditions prevailing, the locomotive is of the six-wheeled coupled type, with wheels 3ft. 4in. diameter, and to enable it to traverse sharp curves the total wheel base is limited to 8ft. 4in. The weight of the locomotive in full running order is 27 tons.

Interleaving for Laminated Springs.

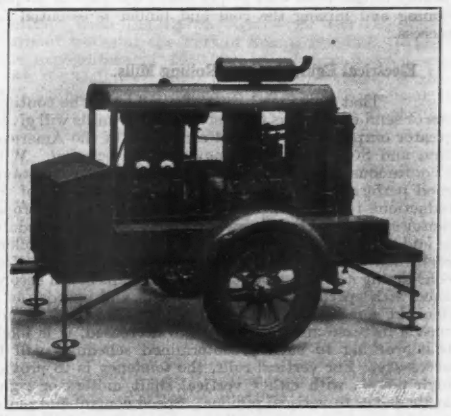
THE popularity of laminated springs for motor car suspension is easily understandable on account of the great resilience which can be obtained in a small space. But in such services they suffer from a disadvantage. As the spring flexes its leaves must slide on one another according to their distances from the neutral axis, and this feature can, in perfect conditions, be taken advantage of in damping out oscillations by the friction of one leaf upon another. In the case of motor car service, however, the conditions of service are so arduous, on account of grit, water, &c., that this merit is lost and the springs wear and squeak. Many efforts have been made to overcome this trouble, such as the enclosure of the spring in a "gaiter" and the employment of grease grooves, and the latest device for the purpose is being put forward by Richard Klinger, Ltd., of 120, Southwark-street, London, S.E.1. It consists in sandwiching between the leaves of the spring layers of weatherproof lubricating material about $\frac{1}{16}$in. thick, which also have a lubricating effect. The material has a woven wire base and is of a fibrous nature thoroughly mixed with graphite. The fibre adheres very thoroughly to the wire mesh and is well smeared with graphite grease before it is put between the leaves of the spring. It is claimed that it will prevent the ingress of the weather and dirt into the spring, check the wear of the leaves, and make them more easy riding. It is, of course, necessary to adjust shock absorbers on account of the greater liveliness of the springs.

The Normal Performance Calculator.

THERE has been sent to us by Tapley and Co., of Southampton, a special form of slide rule known as the "Normal Performance Calculator." By its use it is possible easily and rapidly to calculate from known data of a car or a commercial vehicle the maximum pull it will exert per ton weight in the various gears, and the gradients it will climb, and the range of speed over which it will climb them. It consists of a stout card, 6¾in. by 4in., upon which there is mounted a circular disc. The left-hand edge of the disc bears figures representing the laden weight of the vehicle in cwt., which can be set, in the manner of a slide rule, against an "arc" of figures on the card representing cubic centimetres of cylinder capacity. In this manner the power-to-weight ratio of the vehicle is set on the scales on the assumption that a four-stroke petrol-engined vehicle averages 1 b.h.p. per 100 c.cm. capacity at 1500 r.p.m. when on direct drive. On top of the first disc there is mounted a second bearing on one side figures representing gear ratio which can be set against figures for wheel diameter on the surface of the first disc. Thus, the effect of the overall gear ratio is superimposed on the power-to-weight ratio. Two pointers projecting from the upper disc indicate the maximum pull in pounds per ton on scales on the card. One of these scales is used only for top gear hill-climbing, and the other for top gear acceleration and the lower gears in hill-climbing. In a slot in the top disc there can be read off the range of speed over which this pull will be developed. Allowance is made on the scales for losses due to tyre hysteresis and windage, and also for losses in the gear-box. It is assumed for the purpose of indicating the range of road speeds that the maximum pull is developed at engine speeds between 1000 and 1500 r.p.m. A table on the back of the card converts the pull in pounds per ton into the equivalent gradients climbable at a steady speed. In conjunction with some form of accelerometer, such as the Tapley "Performance" meter, the calculator is of considerable use in determining whether any vehicle is being maintained in good condition. Of course, like any slide rule, the calculator can be used for determining several other matters, such as the engine speed corresponding to any road speed in any gear, or the pull on a low gear from the measured pull on a high gear, &c.

An Oil Engine-Driven Electric Welding Set.

THE welding set shown in the accompanying illustration has been brought to our notice by Welding Processes, Ltd., of Ferry-lane, Forest-road, Walthamstow, E.17. Built for use in Western Australia it consists of a single-cylinder, two-stroke British Junkers oil engine with opposed pistons capable of developing 12 h.p. at 1500 r.p.m., and coupled to a Murex drooping characteristic dynamo which works without separate excitation and stabilising devices. The output is 200 ampères at 30 volts. The complete machine is mounted on a two-wheeled pneumatic-tired trailer, with automatic brakes and folding jacks. On each side of the trailer there are long and narrow boxes for carrying electrodes, spare parts, tools, &c., while at the front end there is a deeper box for storing cables, electrode holders, screens, &c. Removable steel doors, not shown in the illustration, are provided to enclose the engine and dynamo. Complete with its trailer, the set weighs 26 cwt. and can, therefore, be towed by a small car or lorry.



PORTABLE ELECTRIC WELDING SET

American Engineering News.

New Sheet Lead Mill.

To supplement its manufacture of lead pipe, traps, and other products, an American company has recently put in operation a new plant for the production of sheet lead, which is an indication of increasing business. An oil-fired melting pot of 7 tons capacity, made of special heat-resisting cast iron, is supported on the brick combustion chamber, which is lined with fire-brick having an outside layer of insulation and a heavy steel jacket. A mould for slabs 9ft. by 4ft. by 4in. is supported on brick piers, between which are gas burners under the mould. An overhead hoisting trolley handles the slabs and sheets. In the rolling mill the slab is passed between chilled iron rolls 28in. in diameter, and 9½ft. long, the roll opening being adjusted between passes. The top roll is counterbalanced and is held against the adjusting screw by the counterweights. The adjustment is made through worm gearing and a 10 h.p. motor, an indicator showing the operator the width of opening. Both rolls are driven by a 200 h.p. motor and double helical gears. For the tables on both sides of the mill the driven rollers are operated from the bottom mill roll through bevel spur gears, in order that the table rollers may be in synchronism with the mill rolls. The overall length of the tables is 115ft. After the 4in. slab or billet has been reduced to about 1in. in thickness, it is cut by circular discs traversing across the table, and driven by a 10 h.p. motor. Sheets are cut to the required dimensions on a maple-topped steel table having motor-operated drums which pull the cutting knives in both directions across the table. In the overhead runway of the mono-rail or electric trolley hoist system are sections suspended from scale apparatus of 7000 lb. capacity, so that as the loaded trolleys pass the net weight—exclusive of the hoist and its slings—is indicated on a dial. As this sheet lead mill is entirely new and on an unoccupied site, the designers had a free hand in making the most efficient plan or lay-out.

Coal Briquette Developments.

Although little is heard of the coal-briquetting industry in America, it is making steady progress, and new plants have been built by a few coal companies in recent years. Successful manufacture depends upon the proper design of the plant and machinery, and upon an effective and cheap binder made of known materials rather than such secret compositions as have been put forward at times. Successful merchandising depends largely upon the quality, size, and shape of the briquettes. In the eastern part of the country, the briquettes favoured are approximately the sizes of the coals generally used.

They are then of egg, pillow, or barrel shape, favourable to rapid ignition. As large-lump coal is more generally used in the western section, block-shaped briquettes are more favoured there. In any case, the briquettes must be hard enough to withstand breakage in handling, must not deteriorate by weathering, must not absorb more than 2 per cent. of moisture during long exposure, and must hold their shape in the fire without crumbling or softening. Roll presses are largely used, rather than the older plunger presses, although multiple plunger presses are used for the larger block briquettes. Some of the roll presses have two rolls revolving in contact, each roll with corresponding moulds or pockets to produce briquettes of the desired shape. One of these rolls is carried in sliding bearings, and is held in contact with the other by heavy springs. While cement, tar, pitch, flour, and starch are used as binders, the material now most generally used is oil-residuum asphalt, and several oil refineries now dispose of this practically useless by-product by manufacturing binders for use in coal briquetting. A recent development which is the subject of study and experiment is the use of sulphite pitch as a binder. The proportion of binder in the briquette usually ranges from 6 to 10 per cent., but care in proportioning and mixing the coal and binder is essential for success.

Electrical Equipment for Rolling Mills.

That new merchant mills will be of the continuous or semi-continuous type, so that fewer mills will give a greater output, was stated at a meeting of the American Iron and Steel Electrical Engineers' Association. With a continuous mill having a separate motor on each stand, good performance requires an accurate knowledge of the reductions to be used, in order to determine the proper motor speeds and horse-power ratings. Rolling schedules as laid out by the engineers are often ignored by the rollers, each man having his own methods, and these men often considering it impracticable to roll merchant bar in accordance with specific schedules of drafts and speeds, as is done in some beam mills and wire mills. But as mill speeds increase and tolerances are decreased, it is likely that working to such predetermined schedules will be necessary. For vertical rolls, the tendency is to provide high power, with either vertical shaft motors or right-angle drives to vertical pinions. Speed control and motor speed regulation are specially important features for mills intended to roll a great variety of products at high speed. This is effected by the use of direct-current machines with speed ranges by field control of at least two to one. Automatic speed regulators are used in some merchant mills, so that the speed of the entire mill can be changed without changing the bus voltage or the speed adjustments of the individual motors. In the discussion, however, it was argued that too much stress may be laid on speed regulation by elaborate and costly apparatus. At roughing stands, the operator must rely on load indicators as a guide in moving a rheostat. It is simpler and less expensive to have this rheostat directly in the motor field rather than to employ a speed regulator. In a 14in. continuous mill, with delivery speed up to 3000ft. per minute, the speed range of the various motors is as high as five to one. But although none of the driving motors have speed regulators the operation of the mill is highly satisfactory.

Gold Dredgers.

With the present increase in the value of gold there has been a revival of gold dredging in California, although these operations have declined in recent years, as the best ground has been worked out. Higher values make it now economical to work the marginal areas having relatively small content of gold. The Yuba company has put in service a ladder dredge capable of digging to a depth of 150ft. The steel hull is 234 lb. long, 68ft. wide, and 12ft. deep, stiffened by two longitudinal trusses, one on each side of the ladder well. The ladder is of plate girder construction, 200ft. long between centres of shafts of the chain sheaves or tumblers. Its girders are 13ft. 6in. deep and spaced 5ft. 6in. apart. Under it, at midlength, is an idler, 10ft. in diameter, to carry the lower side of the bucket chain, which has 126 manganese steel buckets of 18 cubic feet capacity. The upper tumbler shaft has two spur gears with a train of herring-bone gears from the main drive. The ladder joist has two drums in tandem, each holding 2100ft. of 1¼in. wire rope. Dredged material is dropped from the buckets into a hopper which feeds a revolving screen. The waste product or gravel is delivered ashore by a 44in. belt conveyor on a swinging boom, 250ft. long. The dredge works by swinging in an arc around two steel spuds or piles, each 70ft. long and 3ft. by 5ft. in section. The motor operating the ladder hoist and bucket chain is of 650 h.p., while a 75 h.p. motor operates the winch handling the swinging lines or ropes. Ordinarily the swinging is controlled by a winch operator, but in the new Natomas dredge there is automatic winch control to vary the speed of the winch motor in accordance with the variations in light and heavy digging by the buckets. This is specially important when digging in hard ground or ground varying from hard to medium. Dredging gold-bearing gravel in Montana, under 15ft. of water, is being done with a drag-line excavator, having a 70ft. boom or jib, and a 3-yard bucket. It is operated by a Diesel engine, but the pumps and screens on a separate barge are driven by electric motors, taking current from a transmission line.

River Regulation Works.

Extensive regulation works on the Rio Grande by the United States Government have necessitated agreements with the Mexican Government, since this part of the river constitutes the boundary between the two countries. The design and execution of the works—now in progress—are, therefore, under the direction of an international boundary commission. Work on the American side is done with American forces and equipment, while that on the opposite side is done by Mexican forces and materials, but all under the supervision of the Commission. Below El Paso, the river has a winding course for 155 miles, and floods inundate the adjacent lands. To eliminate the flooding and to rectify the boundary, a direct channel is being formed by dredging and dyking, which will reduce the channel length to 88 miles. Above El Paso, and within American territory, a dam is being built to form a flood-control reservoir of 100,000 acre-feet capacity. At Nogales, both of the opposite cities—American and Mexican—have built flood-protection works on small streams, but acting independently the works were not effective. Under the International Commission a flood-water conduit will be built, about a mile in length. Near the mouth of the Rio Grande the channel has a capacity of only 30,000 cubic feet per second, while floods of 200,000 cubic feet per second come down the river at times. To prevent flooding of the rich agricultural section, international agreements have been made for the construction of 150 miles of floodways or flood-relief channels to carry the excess flow to the Gulf. The present work includes about 300 miles of levees or dykes along the river and floodways; also the construction of protective works at irrigation canals crossing the floodways, and control works to distribute the flood flow to the floodways. To supplement the building of regulation works, extensive hydrographic studies and stream-gauging records are being made, while the Commission has organised a special department to observe river conditions and issue flood warnings in order to prevent further loss of life and property damage.

Two American Aqueducts.

Of two great aqueducts for city water supply in California, that for San Francisco was opened with ceremony on October 28th, while that for Los Angeles is well advanced. Early in the century it was realised that with the rapid growth of San Francisco a new and larger supply of water would be required, and steps were taken to obtain water rights in the Sierra Nevada range, at an elevation of about 4660ft. above sea level, and at a distance of about 170 miles. In these mountains two reservoirs—Lake Eleanor and the Hetch-Hetchy Reservoir—feed a common intake to the aqueduct. The watershed has an area of 713 square miles with an annual precipitation of 40in. The project as adopted in 1910 provides for a supply of 400 million gallons daily by gravity flow, and the generation of 250,000 H.P. by hydro-electric plants. The power development was put in operation in 1925. From the intake, 12 miles below the reservoir, there are tunnels from 3 miles to 20 and 25 miles in length connected by steel pipe lines, one of which is nearly 50 miles long. Construction work was done by a special force organised by the city under the late Mr. O'Shaughnessy as chief engineer. Mr. O'Shaughnessy died only a few days before the official dedication of the completed work. The Los Angeles aqueduct will be 240 miles long from its intake on the Colorado River to the Cajalco reservoir, but beyond this there will be 100 miles of distribution line to reach the city and to serve a group of smaller towns around it. About 140 miles are already under construction. Water will be pumped up to the intake, and there will be other intermediate pumping lifts, the highest point being less than 2000ft. above sea level. On the 240 miles there will be 9½ miles of tunnel, 16ft. in diameter. This length is divided between thirty individual tunnels, of which the longest is 18½ miles. They will be connected by 65 miles of canal, lined with concrete, 56 miles of cut-and-cover conduit, and 28 miles of pipe lines and syphons of pipe or concrete conduits. The cost will be about £44,000,000. All work is being done by contract.

American Railway Affairs.

An important step taken to find means of helping the railways out of the present serious troubles is the recent organisation of the Association of American Railroads, which combines and supersedes the former American Railway Association and the Association of Railway Executives. The earlier organisations were mainly advisory, while the new one will have greater authority. Although the railways are owned and operated by a great number of independent companies, they actually form a complete railway system, since passenger and freight cars travel all over the country in interchange movements, while through routes and joint rates are numerous. Furthermore, under the present severe competition of highway traffic, the through routes and joint operation are of more importance than short and local services. In spite of these conditions, the relations between the several companies have been so loose as to hamper collective action. Under the new organisation, which will act in the capacity of a general staff for the railway system as a whole, there will be an aggressive and united effort to deal with problems affecting the railways as a system, and a leadership which can be obtained only through initiative and co-operation within the railway industry. There is a movement for regulating highway traffic as to rates, services, wages, and working conditions, somewhat as the railways have been regulated for many years. What is really needed, however, is a reduction in the present excessive regulation of the railways and an increase in the present limited and haphazard regulation of highway transportation. Many of the complaints as to backwardness of the railways are due to the severe restriction and heavy taxation now in force. With the prospects of a rapid increase in the use of light-weight, high-speed trains there must be closer relations between the mechanical and civil engineering departments to ensure easy and safe riding of the trains. Greater smoothness of track surface and elimination of low spots and low joints must be obtained, and the problems of curve elevation will have to be studied as affected by new conditions.

Permanent Way Economics.

At the annual meeting of the American Railway Maintenance-of-Way Association an interesting subject presented was the possibility of reducing the continual work of maintenance and renewals by devising a track structure composed of materials not affected by wear or weather and which will retain its original position in spite of loads and stresses to which it is subjected. The conclusion was that such track is almost impracticable and would be economical only for lines carrying extremely heavy traffic. Nevertheless, studies should be continued with the aim of getting greater permanence in track of the present type, and at moderate increase in cost. Various experimental trials in this direction have included:—(*a*) Steel and concrete ties or sleepers; (*b*) concrete slabs under the ballast; (*c*) concrete slabs dispensing with ballast and ties; (*d*) longitudinal supports of steel or concrete under the rails. Probably the nearest approach to permanent construction is in some large modern railway stations, where a concrete floor has pockets for creosoted wood blocks upon which the rails are laid, while concrete bridge floors have been used in which the rails are bolted directly to the concrete. An essential for permanent construction, however, is a stabilised road bed or formation level since the slightest movement or settlement would nullify the "permanence" of the track structure. Another difficulty is that any new type of track construction, designed for permanence, will have an exceedingly high first cost, and even if this should be justified by reduction in maintenance expenses a long period of service would be required to realise a full return upon the investment. On the other hand, it is not generally appreciated that the present type of railway track construction is capable of being made much more permanent, or, in other words, capable of reduction in maintenance work and cost.

LAUNCHES AND TRIAL TRIPS.

JAGERSFONTEIN, twin-screw motor vessel; built by Netherland Shipbuilding Company, Ltd., to the order of United Netherlands Navigation Company, Ltd.; dimensions, 454ft. by 63ft. by 38ft. 8in.; to carry passengers and cargo; trial trip, December 18th.

ROSLIN CASTLE, motor cargo vessel; built by Harland and Wolff, Ltd., to the order of Union Castle Steamship Company, Ltd.; dimensions, 445ft. by 61ft. by 36ft. 9in.; to carry refrigerated cargo. Diesel engines, Harland-B. and W. type; constructed by the builders; launch, December 20th.

TRIASTER, single-screw motor vessel; built by Lithgows, Ltd.; to the order of the British Phosphate Commissioners; dimensions, 400ft. by 58ft. by 37ft., to carry phosphates in bulk and passengers. Diesel engines of B. & W.–Harland and Wolff type; constructed by Messrs. Kincaid and Co., of Greenock. Launch, December 20th.

HOYLE, twin-screw suction sand dredger; built by Cammell Laird and Co., Ltd., to the order of Mersey Docks and Harbour Board; dimensions, 330ft. by 54ft. by 22ft. Engines, triple-expansion, pressure 220 lb. per square inch; constructed by the builders; launch, December 21st.

ROSA, twin-screw steamship; built by Netherland Shipbuilding Company, Ltd., to the order of the Royal Shell Group; dimensions, 335ft. by 56ft. by 14ft. 6in.; to carry oil in bulk. Engines, steam; constructed by Werkspoor, N.V.; launch, December 22nd.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

SPECIALLOID, Ltd., piston manufacturers, announces the appointment of Modern Tool and Equipment Company, Ltd., 12, East Bridge-street, Cromac-square, Belfast, as its main distributor for Northern Ireland.

COCHRANES (MIDDLESBRO') FOUNDRY, Ltd., manufacturers of cast iron and centrifugally made iron pipes, have opened an office in Manchester at 16, Deansgate, Manchester 3, and have appointed Mr. H. S. Davie to be sales representative in Manchester and the north-west.

WE are informed that, owing to the rapid growth and expansion of the business founded by Mr. G. V. Downer, and known as G.V.D. Illuminators, a private limited company of the same name has been formed to take it over and carry out all future contracts and orders. Mr. G. V. Downer is the managing director and chairman of the company, the offices of which are situated at Aldwych House, Aldwych, London, W.C.2.

CALENDARS, DIARIES, &c.

ASSOCIATED BRITISH MACHINE TOOL MAKERS, Ltd., 17, Grosvenor-gardens, S.W.1.—Wall calendar.

ASSOCIATED EQUIPMENT COMPANY, Ltd., Southall, Middlesex.—Desk pad and diary and greeting card.

AVELING-BARFORD, Ltd., Grantham.—Calendar and memorandum pad.

BABCOCK AND WILCOX, Ltd., Babcock House, E.C.4.—Greeting card.

BLACKSTONE AND CO., Ltd., Stamford.—Wall calendar.

GEORGE ELLISON.—Greeting card.

HOLMAN BROTHERS, Ltd., Camborne, Cornwall.—Wall calendar.

KELLY AND SONS, Portugal-street, W.C.2.—Weekly diary pad.

RUSTON AND HORNSBY, Ltd., Lincoln.—Wall calendar.

SHEFFIELD CHAMBER OF COMMERCE.—Greeting card.

HENRY SIMON, Ltd., Cheadle Heath, Stockport.—Wall calendar.

SKEFKO BALL BEARING COMPANY, Ltd., Luton.—Greeting card.

STAVELEY COAL AND IRON COMPANY, Ltd., near Chesterfield.—Diary.

S. S. STOTT AND CO., Haslingden, Rossendale, Lancs.—Wall calendar.

SUBMARINE SIGNAL COMPANY (LONDON), Ltd., 9, Victoria-street, S.W.1.—Wall calendar.

THAMES BOARD MILLS, Ltd., Purfleet, Essex.—Desk calendar.

WAILES DOVE BITUMASTIC, Ltd., Collingwood Building, Newcastle-upon-Tyne, 1.—Pocket diary.

G. AND J. WEIR, Ltd., Cathcart, Glasgow.—Greeting card.

WELIN-MACLACHLAN DAVITS, Ltd., 525, Grand Buildings, Trafalgar-square, W.C.2.—Refill for desk calendar.

FRANK WIGGLESWORTH AND CO., Ltd., Shipley, Yorks.—Diary.

PIONEER WORK BY BRITISH ENGINEERS.—Sir Clement Hindley will preside over a meeting of the Royal Empire Society to be held at the Hotel Victoria on Tuesday, January 15th, at 8.30 p.m., when addresses dealing with the Pioneer Work of British Engineers Overseas will be given by Mr. Ralph Freeman, who designed the Sydney Bridge; Mr. Julian Tritton, who will give a description of some of the more famous harbours and bridges of the Empire; Brigadier-General F. D. Hammond, who will speak on railway development in the Colonies; and Colonel Pollard-Lowsley, on Irrigation in India. Admission will be by ticket, obtainable free from the Royal Empire Society, 17, Carlton House-terrace, S.W.1.

Markets, Notes and News.

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer. A comprehensive list of the prices of materials mentioned below will be found on the next page.

The Continental Steel Trade.

Interest in the Continental situation centres at the moment upon the negotiations between the British iron and steel makers and the Continental Steel Cartel, referred to editorially on page 645. The Continental view seems to be that, although these may be prolonged in the end, some arrangement will be reached. The attitude of the British works is shown by the approach they have made to the Import Duties Advisory Committee, pressing for a favourable answer to their application for higher duties made last July. The Continental steel makers take the view that duties of a prohibitive character in Great Britain would have to be met by an intensified fight for export business, which would, of course, be unprofitable to everyone engaged in the conflict. The domestic affairs of the Cartel are not running smoothly. The agreement binding its members expires in March and, unless it is renewed, the organisation will collapse. It is, of course, extremely unlikely that the discontented elements will go to the length of wrecking the Cartel, which, whatever may be said about it, has worked fairly satisfactorily from the Continental point of view. The chief difficulty is that the Germans, by means of barter transactions, have greatly exceeded their allotment, and adopted a distinctly independent attitude towards the other members when it came to paying fines. The figures up to the end of November show that German exports were about 45,000 tons in excess of the allotment, whilst the French were only 7000 tons, and the Belgian less than 500 tons above their quota. The Luxemburg industry had exported 3500 tons less than its allotment. An attempt has been made to rectify the position by giving the German steel makers the least profitable markets, but the complaint now is that they have invaded the markets from which they were excluded through their system of barter trading. In past years the German steel makers have been susceptible to pressure from French, Belgian, and Luxemburg members, but their attitude now has changed, and they have indicated that they do not propose to alter their methods of business, even to save the organisation. It is generally believed however, that there is a certain amount of bluff in this declaration.

The Pig Iron Market.

Actual business in pig iron has been practically at a standstill this week. Consumers, in many cases, have commenced the end of the year stocktaking and have also taken advantage of the holiday break, which, in some districts, has extended over more than the two days, to undertake repairs to plant. Except, therefore, in cases in which urgent needs have arisen, there has been little in the way of buying, and the few transactions which have taken place have been limited to small parcels. A satisfactory feature of the position, however, has been the manner in which deliveries against contracts have been requested right up to the commencement of the holidays. On the North-East Coast there was great activity immediately before the holidays in keeping up with the requirements of customers. This week has been almost barren so far as business has been concerned, and, of course, deliveries have been suspended. As a result stocks will be added to, since production has proceeded at the blast-furnace works. For some time, however, the margin between the demand and the make has been so narrow that the producers will experience some relief at having slightly larger stocks on hand. In any case, the market is confident that the trade requirements of foundry iron will show a definite expansion early in the New Year that will quickly absorb any surplus iron. In the Midlands, where there is not such a nice adjustment of supply and demand, some undelivered balances against contracts will be carried over into the New Year. Stocks in this district have not been brought down to so low a level, and probably the additions over the holiday period will be heavier. A feature which creates confidence is that the Midland light castings foundries expect to feel the beginnings of the spring demand for their products in a few weeks, and this points to an early revival in the demand for foundry iron. Steady conditions rule in the Scottish pig iron trade. The makers complain of the inroads of English and Indian iron; but production is maintained and stocks are not unwieldy. Consumption is on a satisfactory scale and is sufficient to keep furnaces in operation on foundry. The hematite market has experienced holiday conditions similar to other departments, but the makers are finishing the year with substantial orders on their books. The price of North-West Coast hematite has been reduced for the Sheffield market from £4 delivered to £3 16s. The requirements of the Sheffield steel makers are heavy, and the competition of other makes in this district is probably responsible for the reduction.

Scotland and the North.

The Scottish steel works are experiencing a quiet time so far as new business is concerned, but there is strong pressure to hasten deliveries against contracts before the holidays. The home demand for most descriptions has been well maintained for the time of year, although, naturally, the total volume of business has shrunk perceptibly of late. A considerable tonnage of sh: plates and sections is being turned out, and although contracts with the shipbuilders are being completed rapidly, the requirements of the yards in connection with vessels recently ordered will provide a considerable amount of work for the steel industry in the New Year. The marine engineers are taking fair quantities of material, and the constructional firms have enough work on their books to keep them well employed for some time. The re-rolling department does not make much headway and continues to blame the quantities of Continental steel sold on the Scottish market for the rather unsatisfactory state of their order books. One of their complaints is that the orders they do secure are for the most part for small tonnages, so that rolling programmes are difficult to arrange. The sheet industry, after a spell of moderate activity, is working rather slowly. The demand is principally for the heavy gauges and there is only a fair request for the lighter descriptions. Export business in this department has fluctuated considerably during the year, and at the moment is on a poor scale. The Lancashire market is showing less signs than usual of the slackness which is expected to develop at this time of the year. One reason for this is that the constructional engineering works have a number of good contracts on their books, and are taking good deliveries. The plate manufacturers are not too optimistic concerning the outlook; but at the moment they are maintaining operations at the works at about the rate which has been ruling since September. Competition between the associated and the unassociated works for small bar orders is less noticeable than of late, and prices are inclined to be a little firmer. In this market there is only a small demand for Continental steel, as the operation of the rebates and the duties diverts most of the business formerly passing to the Continent to the British works.

The North-East Coast and Yorkshire.

The market closed for the holidays in a confident mood. A few weeks ago there was some misgiving regarding the prospects for the early part of 1935, but this was removed by the improvement which took place in business in the latter part of November and the beginning of December and by indications that substantial fresh contracts might be placed early in the New Year. Immediately prior to the holidays there was renewed talk that a favourable answer would be given to the steel makers' application for increased duties, and if the Government grants the application it is expected that the North-East Coast works will materially benefit. The manufacturers will start the New Year in a strong position, as in nearly every department they are carrying a good balance of unexecuted orders. The works producing railway material had something in the nature of a Christmas present from the Southern Railway Company, which placed orders for 9000 tons of railway chairs. Further orders are expected to be given out by the companies in the New Year, and it is hoped that the tonnage placed in 1935 will be an improvement upon last year's requirements. The constructional engineers have been working at a good rate of operations for some weeks and just before the holidays took deliveries of steel which will enable them to make a satisfactory restart. In fact, this branch of the trade seems confident that the prospects for next year are distinctly good. The Yorkshire steel industry stopped working for the holidays with healthy order books. Production in the Sheffield district has been at a record rate and the Templeborough concern has continued to turn out 11,000 tons of steel per week from ten furnaces. Business in acid steel has not been so good, but the demand for stainless steel was unabated right up to the holiday stoppage and business in tool steel has been steady for weeks past. Most of the re-rolling shops are well situated as regards orders, but there was some decline in the business transacted prior to the holidays.

The Midlands and South Wales.

Most of the finished steel departments of the Midland works have been closed for most of the week and the merchants' offices have been open only for a short period. The volume of business, therefore, has been insignificant. In the ordinary way business would not become normal until the middle of January, but the market closed for the holidays on a note of confidence and deliveries were made by the steel works right up to the break. This has encouraged expectations that a healthy re-start will be made earlier than usual in the New Year. The constructional engineers are expecting to resume the buying which slackened off a week or two ago very soon, as they have considerable orders in hand and new constructional work is in prospect. This branch of the trade has been busy for some months and has provided a good outlet for joists and sections, and anticipations are rife that the demand from this quarter will further expand next year. Business with the motor manufacturers is also expected to increase. Buying from this department started rather later in the season than usual, and it is, naturally, expected that it will be more prolonged. There has been a good request for special steels and for the type of sheets used in the construction of cars. For the few weeks preceding the holidays there was a distinct falling-off in the demand for small bars and strip. To what extent this was due to the approach of the holidays it is difficult to determine, but the re-rollers consider that the imports of Continental merchant bars and strip have had more to do with it than anything else. There is a considerable margin of price in favour of the Continental material. The associated re-rollers' quotation is £8 12s. less a rebate of 2s. 6d., but Continental material is sold at £7 1s. delivered Birmingham and including the duty. This is also well below the price quoted by the unassociated re-rollers of £7 10s. to £7 12s. 6d. In South Wales the holiday stoppage came at a time when business was passing through a rather quiet phase, and as a result most of the local works will extend their holiday longer than usual. The production for the first eleven months of the year was over 20,000 tons in excess of the corresponding period of 1933. For the time being the export demand for tin-plates has declined, but this is a seasonal movement and the makers are regarding the position with confidence.

Current Business.

The Clan Line Steamers, Ltd., have ordered from the Greenock Dockyard Company, Ltd., a twin-screw steamer of 10,000 tons d.w. for the South African and Australian trades. The contract for the machinery has gone to the North-Eastern Marine Engineering Company, Ltd., of Newcastle. The Southern Railway has placed orders for 9000 tons of railway chairs, the order being divided between Pease and Partners, Ltd. (5000 tons), The Tees-side Bridge and Engineering Company, Ltd. (2300 tons), and Head, Wrightson and Co., Ltd. (1700 tons). The contract for machinery for the cruiser "Birmingham" to be built at Devonport, has been placed by the Admiralty with John Brown and Co., Ltd., of Clydebank. The Booth Steamship Company, Ltd., has placed a contract for a 5000 tons cargo steamer with William Denny and Bros., Ltd., of Dumbarton. Lithgows, Ltd., of Port-Glasgow, have taken an order for an ore-carrying steamer of 8000 tons from the United Steam Navigation Company, Ltd. Edmund Nuttall, Sons and Co., Ltd., and John Mowlem and Co., Ltd., have secured a contract from the Crown Agents for the Colonies for harbour works at the Port of Spain, Trinidad, involving the expenditure of £950,000. Contracts in connection with the Galloway water power scheme valued at about £70,000 have been awarded to Mr. A. M. Carmichael, the public works contractor, of Edinburgh. The Department of Overseas Trade announces that the following contracts are open for tender:—Johannesburg Municipality: 10,200 feet of 9in. and 5500 feet of 18in. wrought iron water piping; 60,000 feet of 1in. solid-drawn screwed and socketted gas piping to B.S. specification (South Africa, January 12th); Johannesburg Electricity Supply Commission: nine traction sub-station equipments for the South African Railways (Johannesburg, February 5th); South African Railways and Harbours: train lamps and fittings (Johannesburg, January 21st); Argentine State Oilfields Directorate: 8000 m. of 4in. and 700 m. of 8in. oil duct piping; 5000 m. of piping to specification No. 00327; and 2000 m. of black steel high-pressure tubes, various, from ¼in. to 4in. diameter (Buenos Aires, January 7th); Viacao Ferrea do Rio Grande do Sul: 2000 kilos. of copper plates; 2000 kilos. of copper rods; 6000 kilos. of brass rods; 2000 kilos of brass sheets; and 700 kilos. of copper wire (Brazil, January 23rd). H.M. Trade Commissioner at Toronto reports that a local firm is interested in the purchase of hot-rolled steel strip in coils from 6$\frac{7}{8}$in. to 6$\frac{7}{16}$in. wide; and a Canadian firm wishes to receive quotations from United Kingdom manufacturers for 2 tons of ½in. and 5 tons of ⅜in. by ¼in. cold-rolled steel strip with rounded edges.

Copper and Tin.

The year is closing with the copper market in a situation of more than usual interest. The market a few weeks ago apparently came to the conclusion that the copper producers would be obliged to cease their policy of price cutting and resort to a scheme for regulating production. As a result there has been an important speculative movement and it must be some time since so much copper was held by interests outside the metal industries. In addition to considerable purchases by Continental operators, a large quantity of copper has been bought and taken off the market to be held as an investment. There is no doubt that the very low price to which the metal had fallen, and anticipations that any scheme of restriction would visualise at least a rise to 9c. per pound—or rather more than 2¼c. above the figure at which the speculative buying first commenced—encouraged this movement. The position is healthy enough up to a point, but if by any chance the producers, at the meeting which it is understood will be held in January, fail to come to terms the reaction may be serious, and there are market interests who fear that if this occurs the value of copper will depreciate to lower rates than have been seen hitherto. Consumers in Great Britain have followed a conservative policy and have not been frightened into the market by the possibility of an advance in prices. The fears that were entertained that the Italian currency decrees would check business with that country have not been realised, and, if anything, the regulations seem to have facilitated fresh business. Germany also has been able to buy a certain amount of copper by reimbursement credits and French consumers have taken a little. The standard market has reflected the situation in electrolytic copper and there is now a large bull account outstanding. . . . No development of interest has occurred in the tin market and the price has been steady at £228 to £228 10s. Whilst it is pegged so effectually by the International control it is unlikely that speculators will venture to operate upon any scale. American buying has again dwindled, but prior to the holidays there were some fair purchases by the Continent. The statistical position continues to improve and it is expected that the figures at the end of December will show a further reduction in the visible supply.

Lead and Spelter.

The same steady conditions rule in the lead market at the end of the year that have characterised it for several months past. The demand for the metal on the Continent shows indications of improving, and although there has been a seasonal decline in business in this country there is no expectation that this is anything more than the result of the holiday conditions which have existed for the past fortnight. Both producers and consumers seem to expect that the British demand will continue on the scale of the past few months. Some Mexican lead recently arrived and until this was absorbed there was a tendency for values to become a little easier. After the holidays, however, the tone of the market was firm and there were indications that, as is often the case in this market, prices would appreciate at the end of the year. The position regarding Empire metal is still causing heartburning. In spite of the decline in the demand for prompt parcels the premium on Empire lead or duty-free lead ex warehouse remains at about 22s. 6d. It is understood that representations have been made to the authorities for the removal or the suspension of the duty, but it is unlikely that these will be successful, as the duty was the result of the Ottawa agreement.

Current Prices for Metals and Fuels.

Makers' official home trade prices, per ton, delivered buyers' stations. Sections, joists and plates are subject to a rebate to home users purchasing only from associated British Steelmakers: joists, 22s. 6d.: plates and sections, 15s. Export orders of 250 tons and over may be subject to special quotations.

PIG IRON.

	Home.	Export.
	(*D/d Teesside Area*)	
N.E. COAST—	£ s. d.	£ s. d.
Hematite Mixed Nos.	3 8 6	3 2 0
No. 1	3 9 0	3 2 6
Cleveland—	(*D/d Teesside Area*)	
No. 1	3 10 0	3 4 0
No. 3 G.M.B.	3 7 6	3 1 6
No. 4 Forge	3 6 6	3 0 6
Basic (*Less 5/– rebate*)	3 7 6	—
MIDLANDS—		
Staffs.—	(*Delivered to Black Country Station*)	
North Staffs. Foundry	3 11 0	—
„ „ Forge	3 6 6	—
Basic (*Less 5/– rebate*)	3 12 6	—
Northampton—		
Foundry No. 3	3 7 6	—
Forge	3 2 6	—
Derbyshire—		
No. 3 Foundry	3 11 0	—
Forge	3 6 0	—
SCOTLAND—		
Hematite, f.o.t. furnaces	3 11 0	—
No. 1 Foundry, ditto	3 12 6	—
No. 3 Foundry, ditto	3 10 0	—
Basic, d/d (*Less 5/– rebate*)	3 7 6	—
N.W. COAST—		
Hematite Mixed Nos.	3 12 6 d/d Glasgow	
	4 0 6 „ Sheffield	
	4 5 6 „ Birmingham	

MANUFACTURED IRON.

	Home.	Export.
LANCS.—	£ s. d.	£ s. d.
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
S. YORKS.—		
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
MIDLANDS—		
Crown Bars	9 15 0	—
Marked Bars (Staffs.)	12 0 0	—
Nut and Bolt Bars	7 5 0 to 7 15 0	—
SCOTLAND—		
Crown Bars	9 12 6	9 5 0
Best	10 2 6	9 15 0
N.E. COAST—		
Common Bars	9 12 6	8 15 0
Best Bars	10 2 6	9 15 0
Double Best Bars	10 12 6	10 0 0

STEEL.

	Home.	Export.
LONDON AND THE SOUTH—	£ s. d.	£ s. d.
Angles	8 10 0	7 7 6
Tees	9 10 0	8 7 6
Joists	8 17 6	7 7 6
Channels	8 15 0	7 12 6
Rounds, 3in. and up	9 10 0	8 7 6
„ under 3in.	8 14 6	—
Flats, 5in. and under	8 14 6	7 2 6
Plates, ¼in. (basis)	9 0 0	7 15 0
„ 5/16in.	9 5 0	8 0 0
„ ⅜in.	9 10 0	8 5 0
„ 7/16in.	9 15 0	8 10 0
„ ½in.	9 10 0	8 5 0
NORTH-EAST COAST—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Plates, ¼in.	8 15 0	7 15 0
„ 5/16in.	9 0 0	8 0 0
„ ⅜in.	9 5 0	8 5 0
„ 7/16in.	9 10 0	8 10 0
„ ½in.	9 5 0	8 5 0
Boiler Plates, ¼in.	9 5 0	8 5 0
MIDLANDS, AND LEEDS AND DISTRICT—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¼in. (basis)	8 17 6	7 15 0
„ 5/16in.	9 2 6	8 0 0
„ ⅜in.	9 7 6	8 5 0
„ 7/16in.	9 12 6	8 10 0
„ ½in.	9 5 0	8 5 0
Boiler Plates, ¼in.	9 7 6	7 15 0 to 8 5 0

STEEL (*continued*).

	Home.	Export.
GLASGOW AND DISTRICT—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¼in. (basis)	8 15 0	7 15 0
„ 5/16in.	9 0 0	8 0 0
„ ⅜in.	9 5 0	8 5 0
„ 7/16in.	9 10 0	8 10 0
„ ½in.	9 5 0	8 5 0
Boiler Plates	9 5 0	8 5 0
SOUTH WALES AREA—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 0
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¼in. (basis)	8 17 6	7 15 0
„ 5/16in.	9 2 6	8 0 0
„ ⅜in.	9 7 6	8 5 0
„ 7/16in.	9 12 6	8 10 0
„ ½in.	9 10 0	8 5 0

IRELAND—	Belfast.	Rest of Ireland.
	£ s. d.	£ s. d.
Angles	8 12 6	8 15 0
Tees	9 12 6	9 15 0
Joists	9 0 0	9 2 6
Channels	8 17 6	9 0 0
Rounds, 3in. and up	9 12 6	9 15 0
„ under 3in.	9 2 0	9 4 6
Plates, ¼in. (basis)	9 0 0	9 2 6
„ 5/16in.	9 5 0	9 7 6
„ ⅜in.	9 10 0	9 12 6
„ 7/16in.	9 15 0	9 17 6
„ ½in.	9 12 6	9 15 0

OTHER STEEL MATERIALS.

	Home.	Export.
Sheets.	£ s. d.	£ s. d.
10-G. to 13-G., f.o.r.	9 0 0	8 15 0
14-G. to 20-G., d/d	10 5 0	9 0 0
21-G. to 24-G., d/d	10 10 0	9 5 0
25-G. to 27-G., d/d	11 2 6	9 17 6

The above home trade prices are for 4-ton lots and over; 2-ton to 4-ton lots, 10s. per ton extra; and under 2-ton lots, 30s. per ton extra.

Galvanised Corrugated Sheets, Basis 24-G.

Home.	£ s. d.
4-ton lots and up	13 0 0
2-ton to 4-ton lots	13 7 6
Under 2 tons	15 0 0

Export: £16 12s. 6d., c.i.f. duty paid India.
„ £11 5s. 0d., f.o.b. other markets.
„ Scandinavian Markets free.

Tin-plates.
20 by 14 basis, f.o.b. Bristol Channel ports, 18/2.
Tin-plate Bars, d/d South Wales Works, £5 7s. 6d.

Billets.	£ s. d.
Basic (0·33% to 0·41% C.)	6 12 6
„ Medium (0·42% to 0·60% C.)	7 2 6
„ Hard (0·61% to 0·85% C.)	7 12 6
„ „ (0·86% to 0·99% C.)	8 2 6
„ „ (1% C. and up)	8 12 6
Soft (up to 0·25% C.), 500 tons and up	5 10 0
100 tons	5 15 0
Rails, Heavy, 500-ton lots, f.o.t.	8 10 0
„ Light, f.o.t.	7 10 0

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	3/3 per lb.	
Ferro Tungsten	3/– per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£23 0 0	7/–
„ „ 6 p.c. to 8 p.c.	£21 12 6	7/–
„ „ 8 p.c. to 10 p.c.	£21 12 6	7/–
„ „ Specially Refined		
„ „ Max. 2 p.c. carbon	£34 0 0	11/–
„ „ „ 1 p.c. carbon	£38 15 0	12/–
„ „ „ 0·70 p.c. carbon	£42 0 0	12/6
„ „ „ carbon free	10d. per lb.	
Metallic Chromium	2/5 per lb.	
Ferro Manganese (loose)	£10 5 0 home	
„ Silicon, 45 p.c. to 50 p.c.	£13 0 0 scale	5/– p.u.
„ „ 75 p.c.	£18 7 6 scale	6/– p.u.
„ Vanadium	12/8 per lb.	
„ Molybdenum	5/3 per lb.	
„ Titanium (carbon free)	9d. per lb.	
Nickel (per ton)	£200 to £205	
Ferro Cobalt	5/3d. per lb.	

NON-FERROUS METALS.

Official Prices, December 27th.

COPPER—		
Cash	£28 3 9 to £28 5 0	
Three months	£28 12 6 to £28 13 9	
Electrolytic	£31 12 6 to £31 15 0	
Best Selected Ingots, d/d Birmingham	£32 0 0	
Sheets, Hot Rolled	£58 0 0	
	Home.	Export.
Tubes, Solid Drawn (basis)	9½d.	9½d.
„ Brazed (basis)	9½d.	9½d.
BRASS—		
Ingots, 70/30, d/d Birmingham	£27 0 0 to £29 0 0	
	Home.	Export.
Tubes, Solid Drawn, 2/1 Alloy	8½d.	8½d.
„ Brazed	10½d.	10½d.
TIN—		
Cash	£228 2 6 to £228 5 0	
Three months	£228 5 0 to £228 7 6	
LEAD:	£10 8 9 to £10 6 3	
SPELTER:	£11 12 6 to £12 0 0	
Aluminium Ingots (British)	£100	

FUELS.

SCOTLAND.

	Export.
LANARKSHIRE—	
(f.o.b. Grangemouth)—Navigation Unscreened	13/– to 13/6
„ Glasgow—Ell	16/–
„ „ Splint	17/–
AYRSHIRE—	
(f.o.b. Ports)—Steam	14/– to 14/6
FIFESHIRE—	
(f.o.b. Methil or Burntisland)—Prime Steam	14/–
Unscreened Navigation	12/6 to 13/–
LOTHIANS—	
(f.o.b. Leith)—Hartley Prime	13/6 to 13/9
Secondary Steam	13/–

ENGLAND.

YORKSHIRE, MANCHESTER—	
B.S.Y. Hard Steams	18/6 to 21/6
Furnace Coke	15/– to 17/6
NORTHUMBERLAND, NEWCASTLE—	
Blyth Best	14/6 to 15/–
„ Second	13/3
„ Best Small	10/6 to 11/–
Unscreened	12/6 to 13/6
DURHAM—	
Best Gas	14/8
Foundry Coke	18/6 to 22/6

SHEFFIELD	Inland.	
Best Hand-picked Branch	24/– to 26/–	—
South Yorkshire Best	21/– to 23/–	—
South Yorkshire Seconds	17/6 to 19/–	—
Rough Slacks	8/– to 9/–	—
Nutty Slacks	7/– to 8/6	—

CARDIFF— SOUTH WALES.	
Steam Coals:	
Best Admiralty Large	19/6
Seconds	19/– to 19/4½
Best Dry Large	18/9 to 19/3
Ordinaries	18/3 to 18/6
Best Bunker Smalls	13/6 to 14/–
Cargo Smalls	11/6 to 12/6
Dry Nuts	22/– to 26/–
Foundry Coke	24/– to 37/6
Furnace Coke	19/– to 21/6
Patent Fuel	21/–
SWANSEA—	
Anthracite Coals:	
Best Large	37/6 to 40/–
Machine-made Cobbles	41/– to 51/–
Nuts	40/– to 50/–
Beans	25/– to 30/–
Peas	19/– to 22/6
Rubbly Culm	11/6 to 12/–
Steam Coals:	
Large	17/– to 20/6

FUEL OIL.

Inland consumption; contracts in bulk.
Exclusive of Government tax of 1d. per gallon.

Ex Ocean Installation.	Per Gallon.
Furnace Oil (0·950 gravity)	3½d.
Diesel Oil	4d.

Manchester prices ½d. per gallon extra.

French Engineering Notes.

(From our own Correspondent in Paris.)

Industrial Difficulties.

THE need for work in the mechanical engineering and allied industries is observable in the importance attached to the expenditure of the supplementary credit of 800 million francs for strengthening the frontier defences. Most of the work will probably go to firms which are already supplying material for the purpose, but there is great anxiety amongst other makers to obtain orders, and from the Ardennes, the Loire, and other industrial centres the Government is implored to make a large distribution of orders as a means of alleviating a critical situation. There is little work available, and what activity is provided by the preparations for putting in hand the programme of public works, is offset by a lack of building enterprise that has reduced the demand for structural material to an almost negligible quantity. Other important undertakings, such as the big hydro-electric and navigation schemes to be carried out by the Compagnie Nationale du Rhône, are held up for various reasons. Attempts to revive public confidence as a means of bringing about a trade recovery have been checked by the failure of the Citroën Company, which had, nevertheless, been anticipated for several months when it was known that the firm's financial difficulties were being staved off by various expedients. The efforts of a group of creditors to put the Citroën Company in bankruptcy had a serious effect on public confidence, and the Government had to use its influence to save the business from total collapse and the permanent closing of factories giving employment to 25,000 hands. The final result has been the institution of ordinary liquidation proceedings, whereby the business will be continued under the control of liquidators with a view to safeguarding the interests of creditors and shareholders and avoiding the disastrous effect of swelling still further the army of unemployed, whose numbers increased last week by more than 10,000. One of the first matters to be considered under this new arrangement is the desirability of raising the prices of Citroën cars. The failure arises from special causes, and should not be taken as reflecting the industrial situation generally. The exceptional dearth of business offers serious problems in many branches of the mechanical engineering industries, which are meeting them by economies in overhead charges and production, and if nothing occurs to increase financial difficulties it is confidently believed that manufacturers will be able to tide over the present critical period, although no time can be lost by the Government in giving effect to the measures now under consideration for extricating industry from its difficult situation. The year closes with a declining iron and steel production, the discharge of men from some rolling mills, and the general running of works on short time with a view to avoiding, as much as possible, the throwing of men out of employment. The early future depends on circumstances outside industrial control.

Foreign Trade.

An analysis of the returns of foreign trade, including those of business done with the Colonies, during the first eleven months of the year shows that producers and manufacturers have been making great sacrifices in order to dispose of their goods and products abroad. The total value of imports was 21,241 million francs, a decline of 4888 millions as compared with the similar period of 1933, and the exports, amounting to 16,243 million francs, were 598 millions less than the total for the same period last year. As regards quantities, it is interesting to observe that while imports showed considerable reductions all round, there were increases in the exports of produce, "material necessary for industry," and manufactured goods, which were up by 2,825,234 tons, with a reduction in value of 598 millions. As nearly one-half of the exports, as represented by value, went to the Colonies and mandated territories, where they are less affected by competitive prices, it is evident that the depreciation must have been chiefly in trade with foreign countries. The decline of home purchases to an unprecedented low level is diverting more attention to foreign trade, the development of which is regarded as indispensable to the country's prosperity, and to that extent the ideas regarding the necessity of maintaining an exclusive industrial nationalism are seriously weakening. It cannot be said that any great hopes are entertained of transacting a considerable amount of business with Russia in machinery and other manufactured goods as the result of the recently signed convention with the Soviet Government, but the French Government has provided credits to Russia for one year for the payment of that country's purchases in France, so that home industries seem assured of receiving orders up to the limit of those credits.

Aviation.

A decree is being prepared fixing conditions for the transport of mails, goods, and passengers over air routes in Africa, which are to be started early in the year. Trial services have been run between Algiers and Brazzaville, on the Congo. The prevalence of sandstorms in the Sahara is, nevertheless, a serious obstacle to day flying at certain seasons, and it is presumed that regular air services can only be safely accomplished with the aid of beacons at night. Other routes are now suggested away from these dangerous zones. The services to be inaugurated will occupy six days from Algiers to Brazzaville and five days on the return journey, while Nigeria will be brought to within 5½ days of London. Though Belgium is marking out her own routes to the Congo, the French consider that the convention providing for collaboration between the two countries still holds good, and that it will be possible to extend the French line from Brazzaville across the Belgian Congo to Broken Hill, where it will join the line to Madagascar. The Franco-Belgian combination is also intended to shorten the journey between Western Europe and the Cape. The French Minister of Air has announced his intention of purchasing machines from abroad with a view to the selection of suitable types which will be manufactured under licence in this country.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

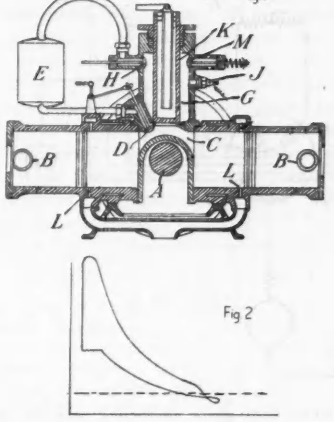
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C. at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES.

419,418. May 14th, 1934.—WORKING CYCLES, B. Silvestri, 28, Viale Monte Nero, Milan, Italy.

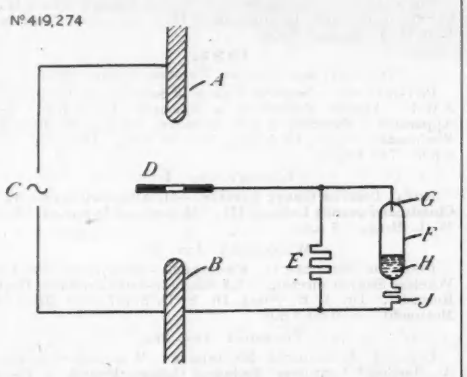
The invention is described as applied to an opposed cylinder engine, with the crank shaft at A and the gudgeon pins of the two cylinders at B, B; but would appear to be adaptable to other types of engine. The pistons work synchronously in opposition and compress a charge of fresh air into the chamber C. This air passes through the gear-controlled valve D and is stored at a high pressure in the reservoir E. The air is carburetted at F and is admitted to the combustion chamber G at appropriate times through the positively operated valve H, where it is exploded by the spark plug J. Communication between the combustion chamber and the chamber C is then established by the lifting of the valve K. At the end of the working stroke exhaust takes place through the ports L L, and fresh air is drawn into the engine, through the valve M, by the impetus of the exhaust. The form of indicator diagram produced by this cycle is shown in Fig. 2.—*November 12th*, 1934.



SWITCHGEAR.

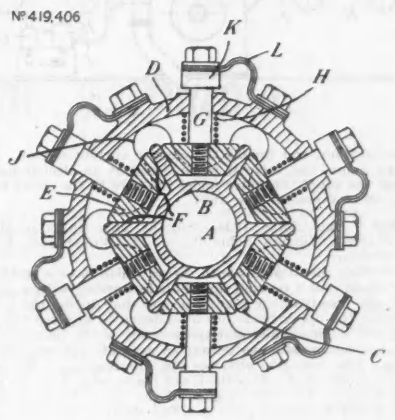
419,274. July 9th, 1934.—MEANS FOR QUENCHING ARCS IN ELECTRIC CIRCUIT BREAKERS, The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C.2.

The present invention is concerned with the extinguishing or quenching of alternating-current arcs, such as may occur in connection with switches or circuit breakers adapted for interrupting high potential circuits. A and B indicate two electrodes of a switch subjected to an alternating potential C, and between which after their separation one from the other an arc forms. In the arc gap an auxiliary electrode D is inserted, in the form of a collar. This auxiliary electrode D is connected through a parallel arrangement of a high-ohmic resistance E, and a discharge device F with anode G and cathode H in series with a resistance J, to one of the main electrodes, for instance, B. Directly after a current zero, the potential at the auxiliary electrode D is at first equal to that of the main electrode B connected to it. Hence, on the potental rising, the arc has the tendency to burn over from A to the auxiliary electrode D. Owing to this, the potential of the auxiliary electrode D rises. When the rise equals the breakdown value of potential for device G, a current flows from A to B *viâ* the electrode D and device G, the space between D and B remaining de-ionised. On the reversal of the potential after the next current zero, the current will tend to take the path—device G, the auxiliary electrode D to the main electrode A. Since now, however, the device G is non-conductive in this direction, no current can flow until a potential is reached which corresponds to the reverse discharge voltage of the tube. If this voltage is sufficiently high, then the time during which the current flow is prevented will be sufficiently long to ensure de-ionisation of the path A/D. The circuit opening is then complete.—*November 8th*, 1934.



419,406. October 25th, 1933.—CONTACTS OF ELECTRICAL SWITCHES, CIRCUIT BREAKERS, ISOLATORS, OR CONNECTORS, Gustaf Adolf Juhlin, of "Redscar," Moss-lane, Timperley, Chester, and Associated Electrical Industries, Ltd., of Crown House, Aldwych, Westminster.

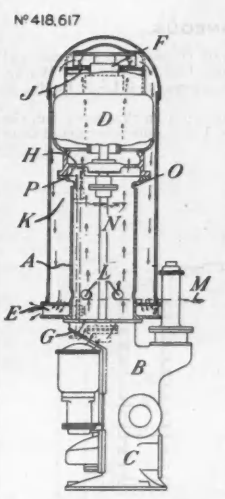
According to this invention, the plug member of switches, &c., is formed or provided with fins or webs extending along it, whilst the socket member carries contact blocks or members which are so mounted as to be resiliently urged against the side faces of the fins or webs of the plug member. The plug member A in the embodiment of the invention shown consists of a hollow cylindrical portion B, and having formed integrally thereon six radially extending fins or webs C. The socket member comprises a housing or carrier ring D, within which six contact blocks E are supported. The contact blocks are provided with flat bevel side faces at F, which are adapted to contact with and lie flat upon the side faces of the fins or webs C. The contact blocks are mounted conveniently by screw-threaded engagement upon the inner ends of respective supporting pins G, which extend slidably through respective perforations provided in the carrier ring D, and the contact blocks are resiliently urged radially inwards by means of respective helical compression springs H encircling the pins G. The springs engage on the one hand with the inner surface of the carrier ring D, and, on the other hand, with the outer surfaces of the contact blocks E. The carrier ring D may be provided with radially extending side webs J, the inner surfaces of which engage with the contact blocks E at the two end surfaces of the latter, whereby to locate the contact blocks against rotational movement about the axes of the pins G, provided with external heads K to limit the inward movement of the blocks E upon withdrawal of the plug member from the socket contact. Each head K may be connected electrically with the carrier ring D by means of a flexible conductor L.—*November 12th*, 1934.



PUMPING AND BLOWING MACHINERY.

418,617. October 2nd, 1933.—SUBMERSIBLE PUMPS, Drysdale and Co., Ltd., of Bon-Accord Works, Ferry-road, Yoker, Glasgow, and John Whitehead Wilson Drysdale, of the same address.

This applies to submersible electrically driven pumps of the type in which the motor, mounted on the same shaft as, and above, the pump, is enclosed in a bell mounted on and surrounding a stool supported by the pump body casting. For submersible pumps of this type it is desirable to provide for circulation of air within the bell, both in the submerged and in the unsubmerged condition of the pump. A denotes a hollow stool surmounting a pump body casting B in the base of which is C an impeller or impellers rotatable on a vertical axis, the impeller shaft being connected by means of a vertical shaft to an electric motor D. The stool and motor are surrounded by a bell with a domed cover. The base of the shell is spaced from the base of the stool by an annular gap E. F is a fan runner mounted on the upper end of the rotor shaft of the motor. In the unsubmerged condition of the pump, air drawn in at G passes upwardly through the interior of the stool A, through the interior of the motor carcase by way of the ports H J, and is discharged by the fan runner downwardly through the annular space K and to atmosphere by way of the annular gap E. When the pump is operating under lip-sealed conditions, *i.e.*, when submerged up to the level of the bottom of the ports L, as indicated at M, the air within the bell is circulated, being induced into the base of the stool through the lateral ports L. When the pump is operating under maximum submerged conditions, *i.e.*, when the water level within the bell is as indicated at N, slightly below the ports O, air is circulated through and around the motor carcase, being induced through the ports in the top of the stool. Manually operable valves, as P, may be provided for controlling the ports H.—*October 29th*, 1934.



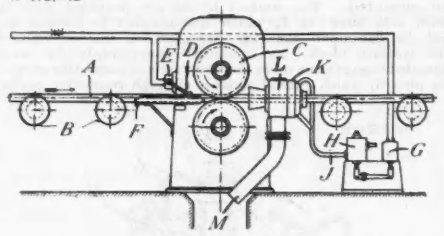
MACHINE TOOLS AND SHOP APPLIANCES.

418,712. November 29th, 1933.—SCALING TUBES, Rudolf Traut, of 69, Friedrichstrasse, Mülheim-Ruhr, Germany.

An improved process is described in this specification for scaling butt-welded tubes. The usual method of dislodging the scale has been found to be incomplete because of the wear on the discharge rings, which in due course sets in more or less rapidly. According to the invention, the discharge rings are in the form of annular spray nozzles, and water under high pressure is discharged from them and directed on to the surface of the tube, the shrinking action of the cold water on the hot iron and the mechanical effect produced combining to cause the complete removal of scale. The tube A, which has been cooled to a predetermined temperature, and which the rollers B of the train of guide rollers convey to the dimensioning rollers C, shortly before it passes into the dimensioning rollers, strikes against the lever D of the switch E, which rests upon the tube-feeding device F. This causes current to flow through the electro-magnet G, and the valve H is opened by the electro-magnet. The water under pressure is thus caused to pass through the tube J and to enter the annular chamber in the nozzle casing K, and is dashed at an inclination against the surface of the tube, some of the water passing into the tube through the front end. In this way the scale adhering to the tube is completely removed. The scale mixes in the scaling device L with the outflowing water, and is discharged through the discharge pipe M into the sinter channel provided below the rolling

mill, where a sinter-collecting box is provided. Immediately the rear end of the tube A has left the tube-feeding device F and passed between the dimensioning rollers C, the lever D, which operates the switch E, falls under gravity back into its

№ 418,712

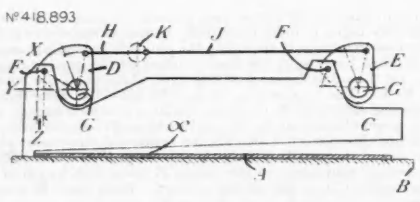


initial position, and breaks the electric current circuit. This, in turn, causes the valve H to be closed by an electro-magnet, so that the supply of water under pressure to the spray nozzle is cut off.—*November 30th*, 1934.

418,893. June 25th, 1934.—SHEARS FOR CUTTING METAL PLATES, Wilhelm Schmidt, of 14, Burgstrasse, Erfurt, Germany.

In cutting metal plates with shears which have a stationary lower blade and a moving upper blade working with a cutting angle, the disadvantage readily occurs that during the cutting operation the upper blade has a tendency to displace the plate being cut longitudinally and transversely of the line of cut, so that it is not possible to obtain an accurate cut according to design. The invention obviates this disadvantage. The metal plate is shown at A; B is the lower blade, while C is the upper blade holder. The cutting edge of the upper blade makes an angle α with the metal plate A. The oblique downward move-

№ 418,893



ment of the upper blade C is effected by moving the upper blade holder by means of two or more bell-crank levers D, E, which are pivoted at F directly to the upper blade holder C, and also at G, to bolts in the machine body, and by one or more driving rods H, J, are connected together and to the drive K of the machine. Consequently, the upper blade holder C describes an arc, the two bolts G forming the centre of curvature and the distance between the points F, G forming the radius. The pivoting points F F, of the two bell-crank levers D, E, therefore, move from the inoperative position X into the position Y. The pivoting points F F, therefore, moves downwardly on the arc of a circle and simultaneously horizontally to the left by the amount Z.—*November 1st*, 1934.

MISCELLANEOUS.

418,751. May 6th, 1933.—KILNS OR OVENS, The International Furnace Equipment Company, Ltd., of Imperial Works, Clement-street-parade, Birmingham, and Leon Bailly, of the same address.

In constructing a kiln in accordance with this invention, the side walls of the heating chamber A are each constructed from

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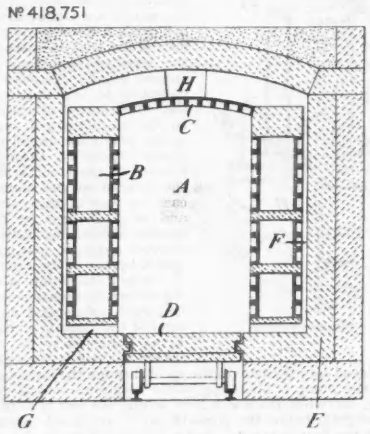
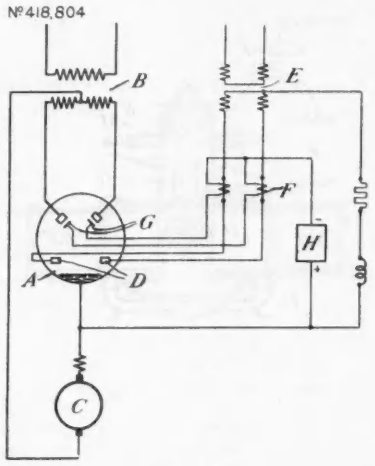


refractory tubular or other hollow bodies B adapted to serve as combustion spaces for the heating gases. The roof C of the chamber is constructed from fire bricks or slabs, and the base D is formed by a conveyor on which the goods to be treated are placed. In the outer structure E, spaces F are provided between it and the side walls and roof of the heating chamber, and at the lower edges of the walls openings G are provided for putting the chamber and spaces in communication. At any convenient position, for example, adjacent to one side of the roof of the heating chamber, a steam or air-operated injector or a number of such injectors may be arranged to set up circulation of hot air in the space, the air being drawn from one side of the lower part of the heating chamber A and delivered at the other side. Alternatively, air may be admitted at an opening H in the roof space and caused to flow down both of the side spaces to the chamber A. By so constructing and operating a kiln or oven the air passing over the roof is heated by contact with the roof, the heated air being admitted to the lower part of the chamber. The interior of the chamber is thus maintained at a more uniform temperature than is ordinarily obtainable.—*October 31st*, 1934.

418,804. April 27th, 1934.—GRID CONTROL SYSTEMS FOR ELECTRIC DISCHARGE VESSELS, Siemens-Schuckertwerke Aktiengesellschaft, of Berlin-Siemensstadt, Germany.

This invention has for its object to provide a simplified and relatively cheap grid control system in which exciter anodes provided in the discharge vessel to be controlled are caused to serve as means for supplying the control potentials for the grids of the main anodes of the vessel in such a manner that the system may be applied to existing discharge vessels in which it is unnecessary for control grids to be provided for the exciter anodes, thus enabling the system to be applied to a wide range of known discharge vessels. The invention is of special importance in respect of locomotive rectifiers which are

№ 418,804



operated with single-phase alternating potential, since with these rectifiers two exciter anodes are normally provided. The circuit diagram of a locomotive rectifier installation is shown, in which the rectifier vessel A is supplied with current through a single-phase transformer B. In the direct-current output circuit of the rectifier the direct-current motor C of the locomotive is connected. The rectifier A is provided with exciter anodes D which are connected through a regulating transformer E to the single-phase mains. In the circuits of the exciter anodes transformers F are connected, and the secondary windings are connected on the one hand to the control grids G for the main anodes of the rectifier, and, on the other hand, through an auxiliary direct-current source H to the cathode of the rectifier.—*October 31st*, 1934.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

SATURDAY, DEC. 29TH.

ROYAL INST. OF GREAT BRITAIN.—21, Albemarle-street, W.1. Christmas Juvenile Lecture, II, "How Electricity Travels," Prof. W. L. Bragg. 3 p.m.

1935.

TUESDAY, JAN. 1ST, TO THURSDAY, JAN. 3RD.

PHYSICAL SOC.—Imperial College of Science and Technology, S.W.7. Annual Exhibition of Scientific Instruments and Apparatus. Tuesday, 3 p.m. to 6 p.m., 7 p.m. to 10 p.m.; Wednesday, 2 p.m. to 6 p.m., 7 to 10 p.m.; Thursday, 3 to 6 p.m., 7 to 10 p.m.

TUESDAY, JAN. 1ST.

ROYAL INST. OF GREAT BRITAIN.—21, Albemarle-street, W.1. Christmas Juvenile Lecture, III, "Motors and Dynamos," Prof. W. L. Bragg. 3 p.m.

WEDNESDAY, JAN. 2ND.

INST. OF ELECTRICAL ENGINEERS.—Savoy-place, W.C.2. Wireless Section meeting. "A Magneto-Striction Echo Depth Recorder," Dr. A. B. Wood, Dr. F. D. Smith, and Mr. J. A. McGrachy. 5.30 for 6 p.m.

THURSDAY, JAN. 3RD.

INST. OF AUTOMOBILE ENGINEERS: WESTERN CENTRE.—At Merchant Venturers' Technical College, Bristol. "Piston Temperatures on a High-speed, Air-cooled Petrol Engine," Mr. H. Wright Baker. 7 p.m.

INST. OF LOCOMOTIVE ENGINEERS.—At Inst. of Mechanical Engineers, Storey's-gate, S.W.1. "A System of Limit Gauging Controlled by Colours with special Application to Locomotive Repairs," Mr. G. L. Murray. 6 p.m.

INST. OF METALS.—James Watt Memorial Inst., Birmingham. "The Microstructure of Electro-deposited Coatings," Mr. A. W. Hothersell. 7 p.m.

ROYAL INST. OF GREAT BRITAIN.—21, Albemarle-street, W.1. Christmas Juvenile Lecture, IV, "Our Electrical Supply," Prof. W. L. Bragg. 3 p.m.

FRIDAY, JAN. 4TH.

INST. OF ELECTRICAL ENGINEERS: METER AND INSTRUMENT SECTION.—Savoy-place, W.C.2. "Theoretical and Practical Sensitivities of Gas-focussed Cathode-ray Oscillographs, and Effects of the Gas on their Performance," Professor J. T. MacGregor-Morris and Mr. J. A. Henley; "A Cathode-ray Oscillograph Equipment Embodying a High-voltage, Gas-filled, Sealed-glass Oscillograph Tube," Professor S. Parker Smith, Mr. C. E. Szeghö, and Mr. E. Bradshaw. 6 p.m.

INST. OF SANITARY ENGINEERS.—Caxton Hall, S.W.1. Presidential address, Mr. W. E. Blizard. 6 p.m.

JUNIOR INST. OF ENGINEERS.—39, Victoria-street, S.W.1. Informal meeting. Lecture, "Notes on Fine Measurement," Mr. F. H. Rolt. 7.30 p.m.

SATURDAY, JAN. 5TH.

ROYAL INST. OF GREAT BRITAIN.—21, Albemarle-street, W.1. Christmas Juvenile Lecture, V, "Telegraphs and Telephones," Prof. W. L. Bragg. 3 p.m.

MONDAY, JAN. 7TH.

ROYAL AERONAUTICAL SOC.—At Inst. of Electrical Engineers, Savoy-place, W.C.2. "Imperial Air Routes," Lt.-Commander B. W. Galpin. 6.30 p.m.

SOC. OF CHEMICAL INDUSTRY.—At Rooms of Chemical Soc., Burlington House, W.1. Jubilee Memorial Lecture. "The Fats: New Lines in an Old Chapter of Organic Chemistry," Professor T. P. Hilditch. 8 p.m.

TUESDAY, JAN. 8TH.

INST. OF AUTOMOBILE ENGINEERS.—At Royal Soc. of Arts, John-street, Adelphi, W.C.2. Presentation of Simms Gold Medal to Mr. A. H. Roy Fedden. "A Study of Road Performance," Mr. Maurice Platt. 7.45 p.m.

INST. OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND: JOINT MEETING WITH INST. OF ELECTRICAL ENGINEERS, SCOTTISH CENTRE.—39, Elmbank-crescent, Glasgow, C.2. "Generation, Distribution, and Use of Electricity on Board Ship," Messrs. C. Wallace Saunders, H. W. Wilson, and Dr. R. G. Jakeman. 7.30 p.m.

INST. OF MARINE ENGINEERS.—The Minories, E.C.3. "Some Notes on Heat Transmission," Mr. E. F. Spanner. 6 p.m.

ROYAL INST. OF GREAT BRITAIN.—21, Albemarle-street, W.1. Christmas Juvenile Lecture, VI, "Oscillating Electrical Circuits," Prof. W. L. Bragg. 3 p.m.

SHEFFIELD METALLURGICAL ASSOC.—198, West-street, Sheffield, 1. Annual general meeting. 7.30 p.m.

SOC. OF GLASS TECHNOLOGY.—Trocadero Restaurant, London. Annual dinner. 7.15 p.m.

WEDNESDAY, JAN. 9TH.

INST. OF CHEMICAL ENGINEERS.—Joint meeting with London Section of Soc. of Glass Technology. In Rooms of Chemical Soc., Burlington House, W.1. "A Review of Some of the Problems of the Glass Bottle Industry," Mr. W. A. Moorhead. 6 p.m.

INST. OF ELECTRICAL ENGINEERS: N. MIDLAND STUDENTS.—Imperial Hotel, Briggate, Leeds. Hot-pot Supper and entertainment. 8 p.m.

THURSDAY, JAN. 10TH.

INST. OF METALS.—At Rooms of Soc. of Motor Manufacturers and Traders, Ltd., 83, Pall Mall, S.W.1. "The Manufacture and Uses of Powdered Metals," Mr. J. C. Chaston. 7.30 p.m.

FRIDAY, JAN. 11TH.

INST. OF MECHANICAL ENGINEERS.—Storey's-gate, S.W.1. Informal meeting, "Automatic Railway Signalling," Mr. E. E. Pierce. 7 p.m.

SATURDAY, JAN. 12TH.

INST. OF MARINE ENGINEERS: JUNIOR SECTION.—The Minories, E.C. Dance. 7.30 p.m. to 11.15 p.m.

MONDAY, JAN. 14TH.

INST. OF CIVIL ENGINEERS: BELFAST AND DISTRICT ASSOC.—Physics Lecture Theatre, Queen's University, Belfast. "Precast Reinforced Concrete and its Use on Railway Work," Mr. W. F. Beatty. 5.45 for 6.30 p.m.

INST. OF METALS.—At 39, Elmbank-crescent, Glasgow, C.2. "Some Aspects of the Corrosion of Non-ferrous Metals," Prof. C. O. Bannister. 7.30 p.m.

TUESDAY, JAN. 15TH.

INST. OF AUTOMOBILE ENGINEERS.—King's Head Hotel, Coventry. "A Study of Road Performance," Mr. Maurice Platt. 7.30 p.m.

INST. OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—39, Elmbank-crescent, Glasgow, C.2. "Passenger Aeroplane Design," Major R. H. Mayo. 7.30 p.m.

INST. OF METALS.—James Watt Memorial Inst., Birmingham. "The National Smelting Works, Avonmouth," by a Member of the Staff. 7 p.m.

WEDNESDAY, JAN. 16TH.

INST. OF AUTOMOBILE ENGINEERS.—Queen's Hotel, Leeds. "The Utilitarian Æsthetics of Automobile Body Design," Mr. W. O. Pennington. 7.15 p.m.

THURSDAY, JAN. 17TH.

INST. OF MARINE ENGINEERS: JUNIOR SECTION.—The Minories, E.C. Film display and lecture, "The Manufacture of Aero Engines," Mr. J. D. Pearson. 7 p.m.

FRIDAY, JAN. 18TH.

RAILWAY CLUB.—57, Fetter-lane, E.C.4. "The Eastern Section of the Great Central Railway," Mr. E. B. Woodruffe-Peacock.

END OF VOL. CLVIII.

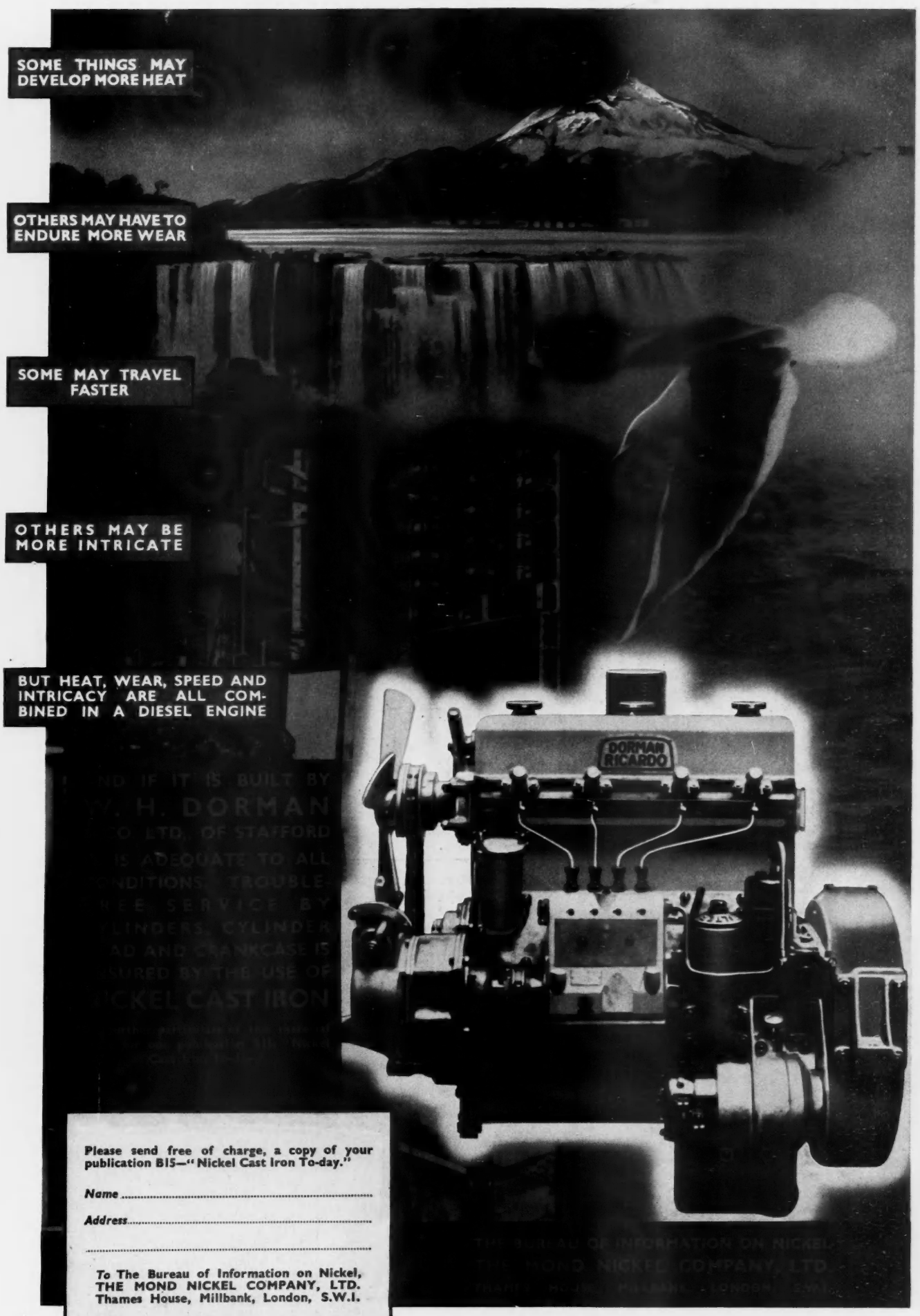
Engineering Library

JAN 12 1935

The Engineer

ESTABLISHED 1856. REGISTERED AS A NEWSPAPER.

VOL. CLVIII.—No. 4120] 28, ESSEX ST., LONDON, W.C. 2. [DECEMBER 28, 1934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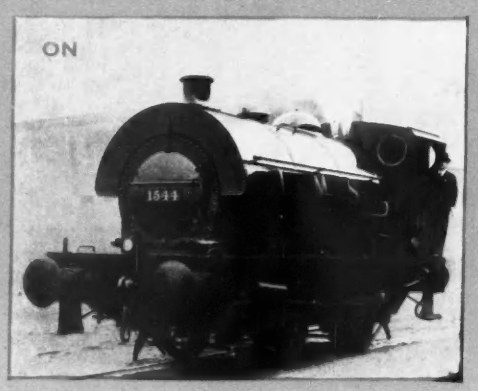

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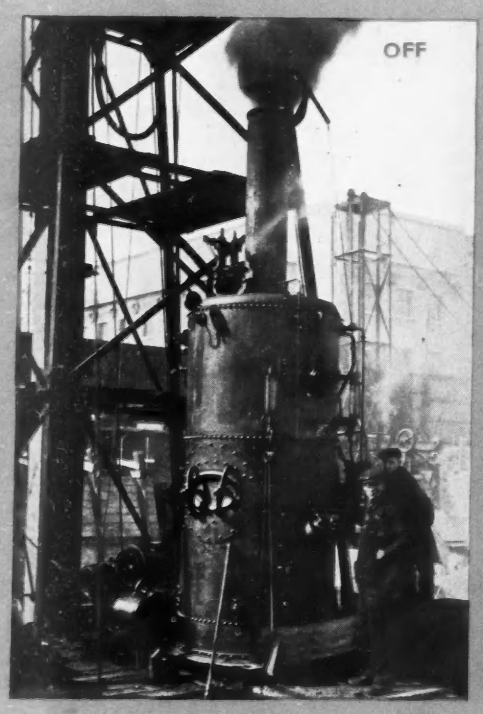

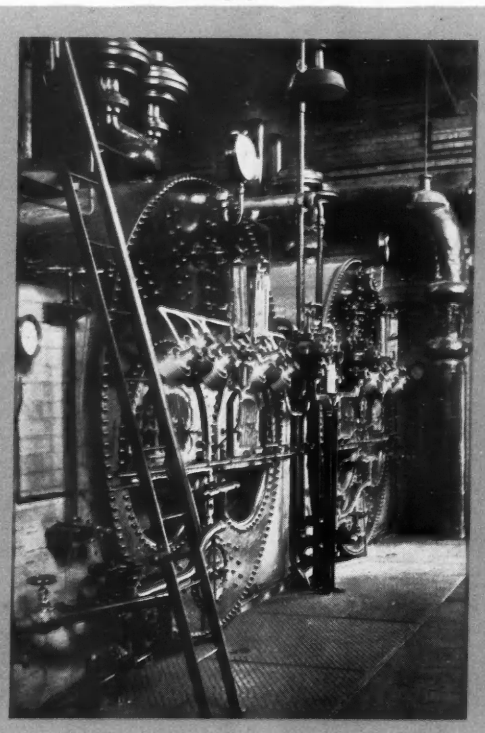

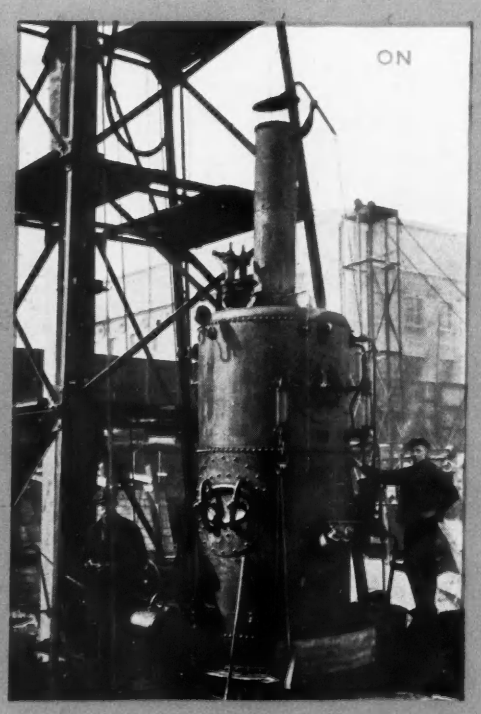

Printed on Thin Paper for Foreign Circulation.

"THE ENGINEER," DECEMBER 28, 1934.

With METALLURGICAL SUPPLEMENT.

The Engineer.

Established 1856.

Registered as a Newspaper.

OFFICE FOR ADVERTISEMENTS & PUBLICATION, 28, ESSEX ST., STRAND, LONDON, W.C.2.

VOL. CLVIII.—No. 4120] LONDON: FRIDAY, DECEMBER 28, 1934 [PRICE { WITH SUPPLEMENT } ONE SHILLING BY INLAND POST 1s. 3d.

PUBLIC NOTICES.

Bradford Education Committee

TECHNICAL COLLEGE, BRADFORD.

APPLICATIONS are INVITED for the APPOINTMENT of ASSISTANT LECTURER in the Department of Mechanical Engineering.

Applicants with a good honours degree in engineering and industrial experience preferred.

Salary according to the Burnham Award, which is from £186 to £480 per annum, less the national approved temporary deduction. Commencing salary according to qualifications and experience.

Further particulars of the appointment, and forms of application, may be obtained from the Director of Education, Town Hall, Bradford, and completed forms should be returned to the Principal of the College not later than 15th January, 1935.

THOS. BOYCE,
Director of Education.

3719

City of Birmingham Electric

SUPPLY DEPARTMENT.
ASH DISPOSAL PLANT.

The Electric Supply Committee invites TENDERS for the SUPPLY, DELIVERY, ERECTION, TESTING, and PUTTING TO WORK of an ASH-DISPOSAL PLANT at Hams Hall Power Station, Lea Marston, Warwickshire.

The plant is required in connection with the five new boilers now in course of erection and four future boilers, and is to comprise Ash Sumps, Sluice Channels, Telpher Gear, Pumps, Piping, Valves, &c.

The general conditions of contract (which include the Corporation's usual Fair Wages and Conditions of Labour Clause), specification and drawings, may be obtained from the City Electrical Engineer, 14, Dale-end, Birmingham, 4, to whom application must be made before 9 a.m. on Monday, 31st December, 1934, accompanied by a deposit of £2, which will be returned on receipt, by the appointed time, of a bona fide Tender, not subsequently withdrawn. Cheques must be made payable to the City of Birmingham Electric Supply Department.

SEALED TENDERS, enclosed in the special envelope provided and endorsed for the purpose, must be delivered to the undersigned NOT LATER THAN 9 a.m., Wednesday, 16th January, 1935, when they will be opened. Tenders not complying with the foregoing will be rejected.

The Committee does not bind itself to accept the lowest or any Tender.

E. J. JENNINGS,
Secretary and Commercial Manager.

14, Dale-end,
Birmingham, 4. 3720

Egyptian Government.

TENDERS are being called for by the Mechanical and Electrical Department, Ministry of Public Works, for the CONSTRUCTION of OVERHEAD TRANSMISSION LINES for Fua and Balamoan Pumping Stations.

Tenders should be submitted direct to the DIRECTOR-GENERAL, Mechanical and Electrical Department, Ministry of Public Works, Cairo, not later than Noon on 5th March, 1935.

Copies of the necessary conditions of Tender, specifications and drawings, &c., can be obtained on application to the Chief Inspecting Engineer, Egyptian Government, 41, Tothill-street, London, S.W.1, against remittance of £1 0s. 6d. per set, which sum is not returnable.

Copies of these documents are also available for scrutiny at the above address.

Firms on the Continent should apply to the Egyptian Consulate in their respective countries for the above-mentioned documents. 3708

Borough of Ealing.

APPLICATIONS are INVITED for the following APPOINTMENTS on the Staff of the Borough Engineer and Surveyor :—

1. ASSISTANT BOROUGH ENGINEER and SURVEYOR,

at a commencing salary of £500 per annum, rising by annual increments of £25 to a maximum of £650.

The Official appointed will be required to provide and maintain a motor car for use in the course of his duties, towards which a car allowance of £78 per annum (or such other sum as the Council may from time to time determine) will be paid.

Applicants, who must be not more than thirty-five years of age, must be Chartered Civil Engineers, and have held previous Municipal Appointments.

2. ARCHITECTURAL ASSISTANT,

at a commencing salary of £300 per annum, rising by annual increments of £10 to a maximum of £400 per annum.

Applicants must be Chartered Architects, and should preferably have had experience in Design and Construction of Schools, Hospitals, Libraries, and other Municipal Buildings.

3. TECHNICAL ASSISTANT for STEELWORK and REINFORCED CONCRETE,

at a commencing salary of £300 per annum, rising by annual increments of £10 to a maximum of £400 per annum.

Applicants should be fully qualified and be thoroughly competent in the Design of Steel and Reinforced Concrete Structures, and familiar with the Regulations and Codes of Practice of the London County Council in respect of Steelwork and Reinforced Concrete.

Preference will be given to qualified applicants who are Chartered Civil Engineers, but applicants with other professional qualifications will also receive consideration.

The appointments referred to above are subject to the provisions of the Local Government and Other Officers' Superannuation Act, 1922, and the successful candidates will be required to pass the necessary medical examination.

Applications are to be made on forms to be obtained from Mr. F. J. Forty, B.Sc., A.M. Inst. C.E., Borough Engineer and Surveyor, Town Hall, Ealing, W.5.

Applications, in envelopes endorsed "Assistant Borough Engineer and Surveyor," "Architectural Assistant," or "Technical Assistant for Steelwork and Reinforced Concrete," as the case may be, stating age, experience, and qualifications, accompanied by copies of not more than three recent testimonials, are to be sent to the undersigned not later than Wednesday, the 2nd January, 1935.

Canvassing is prohibited, and will disqualify.

Dated this 14th day of December, 1934.

R. H. WANKLYN,
Town Clerk.

Town Clerk's Office,
Town Hall,
Ealing, W.5. 3668

The Engineer

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PUBLIC NOTICES.

Liverpool Corporation Water-Works.

VYRNWY AQUEDUCT - THIRD INSTALMENT.
MALPAS TO NORTON SECTIONS.
CONTRACT No. 23 : PIPE-LAYING.

The Water Committee of the Liverpool Corporation is prepared to receive TENDERS from competent persons willing to enter into a Contract for the LAYING of STEEL PIPES of 42in. internal diameter and other Ancillary Works, as follows :—

From Malpas to Ashton's Cross, and from Brown Moss to River Weaver, a total distance of about 3 2-3 miles.

The plans and sections may be inspected, and copies of the specification and form of Tender obtained, at the Water Engineer's Office, 55, Dale-street, Liverpool, 2, upon payment of a deposit of Five Guineas, which will be repayable upon receipt of a bona fide Tender, and return of the documents issued.

Tenders, endorsed "Tender for Third Instalment Pipe Laying," are to be sent through the post in a sealed envelope, addressed to "The Town Clerk, Municipal Buildings, Liverpool, 2," so as to be delivered not later than Twelve o'clock Noon on Thursday, 17th January, 1935.

The Water Committee do not bind themselves to accept the lowest or any Tender.

WALTER MOON,
Town Clerk.

Municipal Buildings,
Liverpool, 2,
December, 1934. 3664

Metropolitan Police.

APPLICATIONS are INVITED for the POSITION of ASSISTANT ENGINEER, Grade I, at a commencing salary of approximately £510 per annum. The appointment is tenable on the usual Civil Service conditions.

Candidates should normally be between the ages of 35 and 45 years of age.

QUALIFICATIONS.

A candidate must have had a sound theoretical and practical training in Electrical and Mechanical Engineering, and must be a Corporate Member of the Institution of Electrical Engineers.

He must also have had good general Engineering Experience, particularly in regard to the provision and Maintenance of Lighting and Central Heating Installations.

A knowledge of Radio Engineering is desirable.

Until 7th January, 1935, further particulars and forms of application may be obtained from the ENGINEER'S GENERAL OFFICE, Office of the Receiver for the Metropolitan Police District, New Scotland Yard, S.W.1. 3698

PUBLIC NOTICES.

Croydon Mental Hospital

WARLINGHAM, SURREY.

ASSISTANT ENGINEER REQUIRED for a large Institution Plant. Age not to exceed 35. Applicants must produce indentures of having had a thorough practical (workshop) training and possessing technical knowledge in mechanical engineering and must be prepared to do and capable of carrying out repairs to boilers, engines, electrical plant, steam engine fittings, heating and hot water systems, &c., as required. A knowledge of electrical generating plant, mains, battery and general appliances is essential.

Wages £5 10s. per week, subject to a deduction of 3 per cent. for superannuation under the Asylum Officers' Superannuation Act, 1909. The appointment will be on probation for 6 months, when, if service and medical examination at the Hospital are satisfactory, it will be confirmed.

Applications, with copies of two recent testimonials, to be sent to me not later than the 21st January, 1935.

J. M. NEWNHAM,
Town Clerk,
Clerk to the Committee.

Town Hall, Croydon,
18th December, 1934. 3709

SITUATIONS OPEN.

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

TO ADVERTISERS UNDER BOX NUMBERS IN THIS CLASSIFICATION.

For the benefit of applicants, the Proprietors are prepared to insert brief notices that vacancies are filled, upon receipt of notifications from the Advertisers. These notices (limited to one line) will be free of charge, and co-operation is asked for.

Box 3042.—Position Filled ; Applicants Thanked.

WANTED, ENGINEER SALESMAN. Must have practical knowledge of Steel, Hydraulics, and Workshop Machinery ; essential applicants have had Sales Experience in London and Home Counties.—Box 3026, "Homefinders," 74, Victoria-street, S.W.1. 3705 A

ENGINEERS REQUIRE TECHNICAL MAN, with good connection as Sales Representative in London and provinces. Salary £250 and expenses.—Address, 3725, The Engineer Office. 3725 A

SITUATIONS OPEN (continued).

ENGINEER WANTED, PRACTICAL, to Invest and Take Charge of Small Shop and generally Assist to Improve Small Tool Works. Man with good character and capable of taking loyal charge. Small wages to commence and to increase as business progresses. S.E. London.—Address full particulars, 3718, The Engineer Office. 3718 A

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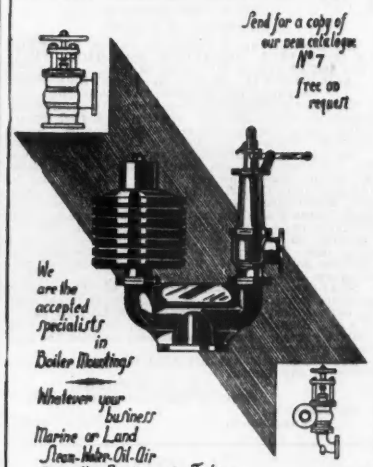
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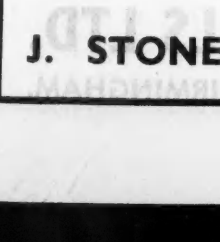

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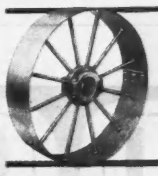

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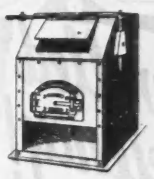

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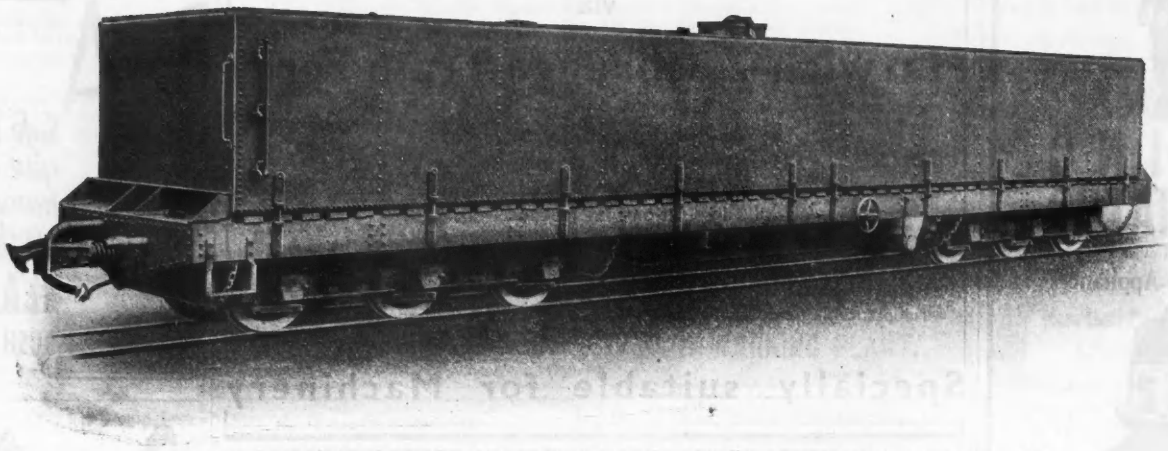

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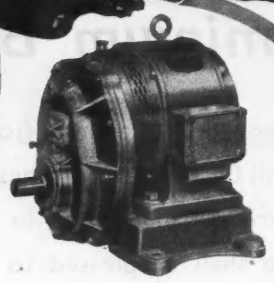

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1 Washing Pump and Gear, electric-drive, with tank and hose. Ref. No. 349.
1 30-cwt. "Denison" Portable Scales, platform 42″ x 42″. Ref. No. 314.
30 Fitters' Vices—quick release pattern.
2 "Record" Carpenters' Vices.
10 Electric Drills comprising :—
3—¼″ "Wolf" Pistol type.
3—¼″ "Vidal" " "
1—¼″ "Black and Decker" " "
1—½″ "Vidal" Drill
2—½″ Drills.
1 "B.E.N." Portable Electric Compressor, with receiver, 20″ x 48″, 1½ h.p. motor, silent V-belt drive to compressor, 7 cub. ft. displacement, 2 5-gall. Paint containers, 2 spray pistols with 1-quart containers, 2 air lines, 1 fluid line.
2 Garage Jacks—48″ x 15″—travelling and steering type.
1 Slingsby Elevating Truck, 6 platforms.
3 Workshop Trucks, 30″ x 18″.
3 Engine Stands.
5 Sets Chain Lifting Blocks—various
17 Tool or Work Stands, 24″ x 17″ x 39″ high, 3 tiers with trays.
1 Set 7-lb Balance Scales with weights.
1 C. I. Box Angle Plate—slotted on 5 sides, 30″ x 18″ x 24″.
1 C. I. Angle Plate—slotted 3 sides, 18″ x 11″ x 15″.
1 Marking Out Table, 6′ x 3′ on iron stand.
1 Marking Out Table, 5′ x 3′ on iron stand.
1 Marking Out Table, 5′ x 3′ on wooden stand.
2 C. I. Machines, Plated, 5′ x 1′ 2″ on wooden stand.
2 Erection Bedplates, 5′ x 4′ x 5″ with 2 T-slots.
5 Surface Plates, 1′ 6″ x 1′ 6″.
1 Surface Plate, 3′ x 2′.
260ft. 2½″ Shafting.
30 2½″ "Hyatt" Roller Brg. Plummer Blocks.
4 2½″ Muff Couplings.
9 2½″ Compression Couplings.
1 11′ 2″ Shafting.
1 10′ 2″ "
1 12′ 1½″ "
1 2″ Compression Couplings.
3 C. I. Wall Brackets—14″ to centre.
3 1½″ A—Standards with bearings.
2 Gas Stoves.
1 Canteen Cupboard.
2 Gledhill-Brook Time Recorders with double rack.
1 "Black & Decker" ⅜″ Electric Valve Refacer and Grinder.
1 Galv. Rect. Closed Tank, 18″ x 32″ x 23″ high, with ¼″ tap.
3 Garage Oil Tanks with pumps, 21″ x 50″ x 30″ high.
3 Garage Oil Tanks with pumps, 21″ x 25″ x 30″ high.
2 800-gall. Oil Storage Tanks.
1 400-gall. Oil Storage Tank.
1 1,400-gall. Oil Storage Tank.
1 1,500-gall. Oil Storage Tank.
1 Petrol Pump.
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4 Fitters Benches, 20′ x 4′ 6″ (double width).
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1 Carpenters' Bench, 7′ x 2′ 3″.
Trestles.
Ladders.
Micrometers, Tools and Gauges.
1 Pyrometer (incomplete).
4 Store Bins.
Tool Cupboard.
Stores—miscellaneous items.
Tools—miscellaneous items.

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3 20 h.p. "Brook" Motors, 200 v., 1 phase, 50 cycles, 1000 r.p.m., with starters.
1 7 h.p. "Brook" Motor, 200 v. etc., 1500 r.p.m., with starter.
1 4 h.p. "Brook" Motor, 200 v. etc., 1500 r.p.m. (end plates broken).
1 Battery Charging Set, comprising B.T.H. D.C. generator, 900 r.p.m., output 72 amps. at 125 volts, belt-driven from 7·5 h.p. "Brook" motor, 200 v. etc., 1500 r.p.m., starter switch, double instrument panel with voltmeters, ammeters, cut-outs, rheostats, and 4 pavis leads and connecting plugs.
1 Battery Charging Set, comprising "Brook" D.C. dynamo, output 30 amps. at 40 volts, direct-coupled to 3 H.P. "Brook" motor, 200 v. etc., 1400 r.p.m., with switch and starter, instrument panel with voltmeter, ammeter, rheostat and D.P. switch.
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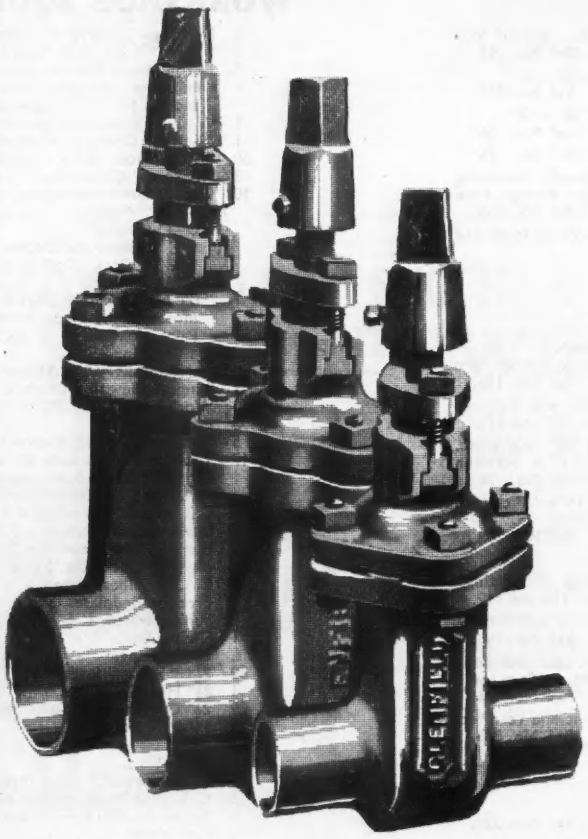

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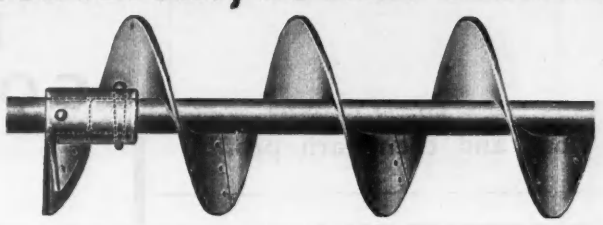

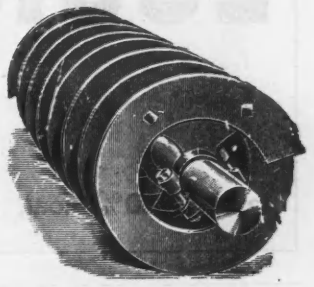

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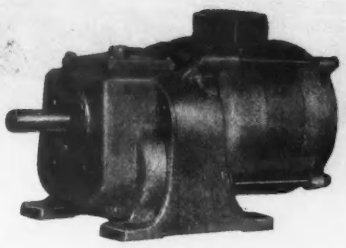

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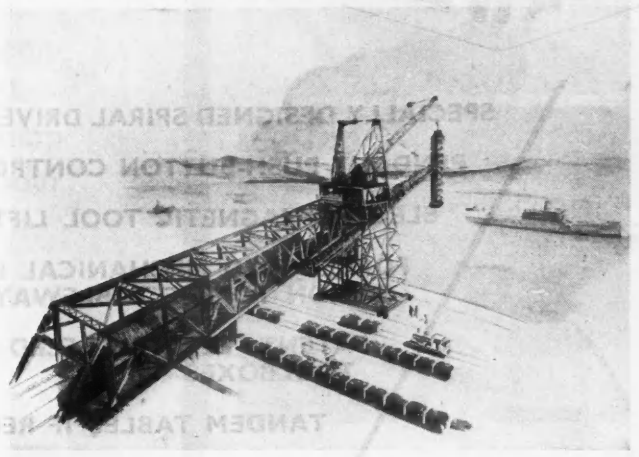

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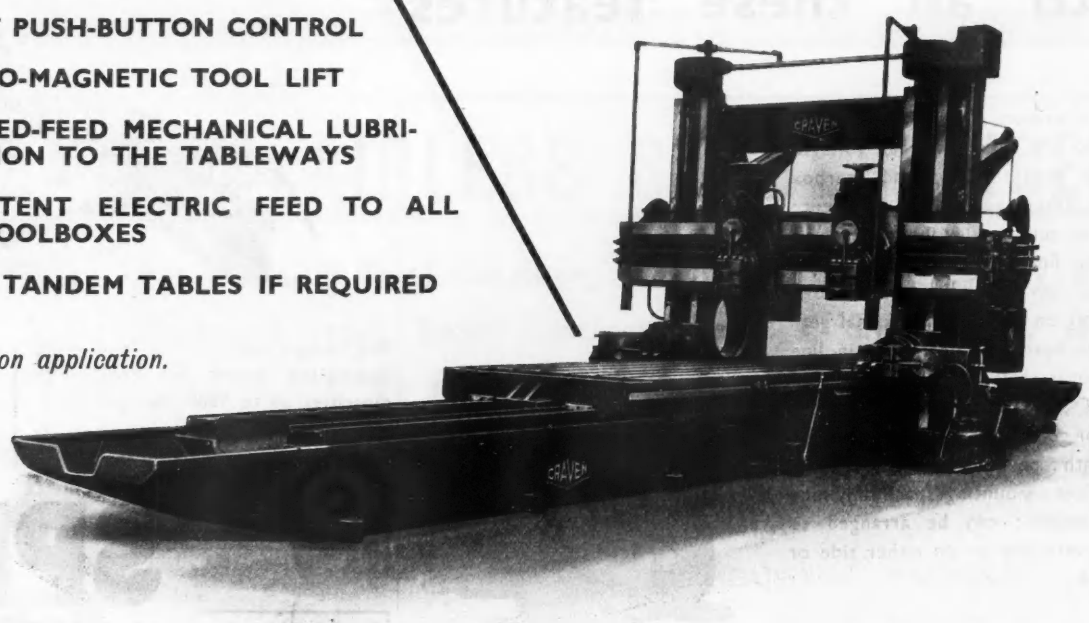

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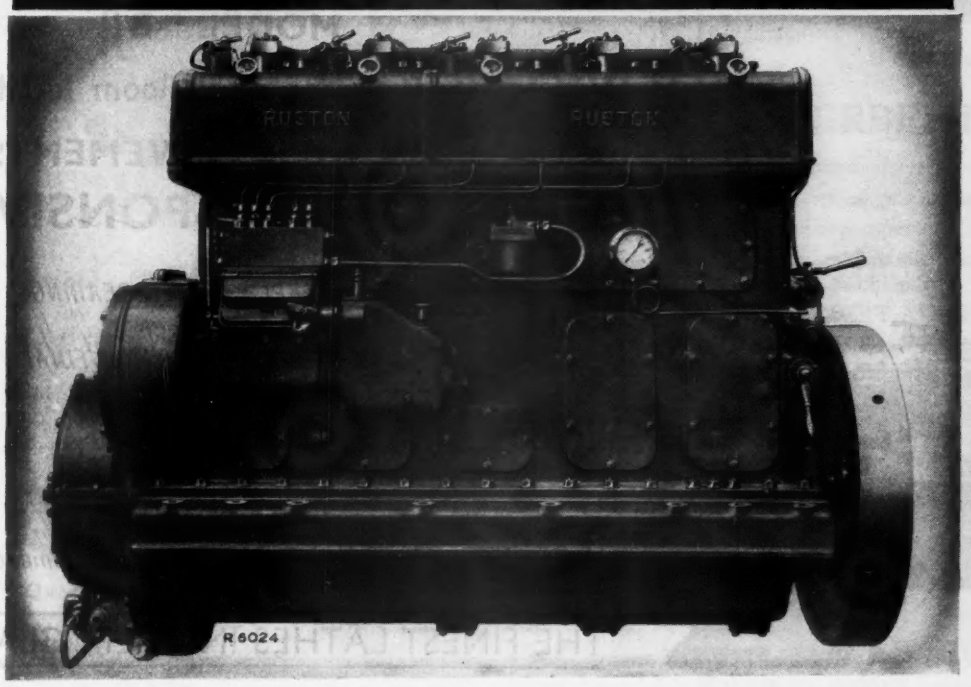
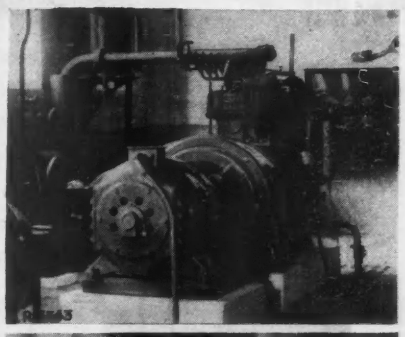
A *NEW* RUSTON Oil Engine . . .

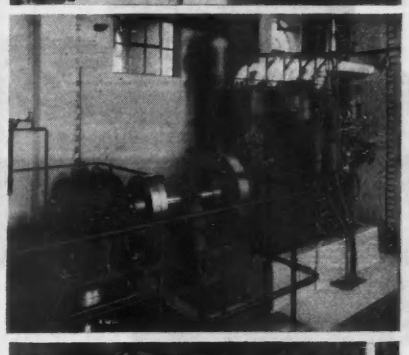


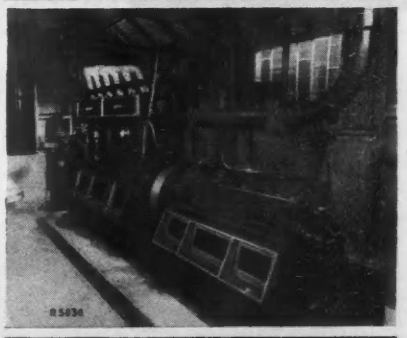
The latest development in the Ruston range of oil engines is a vertical unit developing 17½ B.H.P. per cylinder at 1,000 r.p.m.

It has been designed for mounting direct on to a concrete base. Some of its features are: four stroke principle—airless fuel injection system—cold starting—dry sump lubrication—totally enclosed design—no skilled labour required to operate.

This new engine is made in a range of sizes from 2 to 6 cylinders with powers from 35 B.H.P. to 106 B.H.P.







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Full particulars of this NEW Ruston engine are contained in an attractive catalogue, a copy of which will be sent to you free on request.

B

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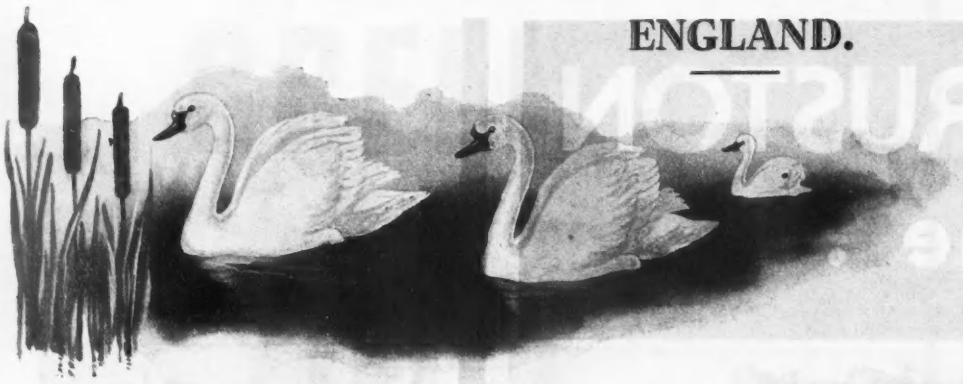

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the movements of the swans
on still water,
but cannot hear them

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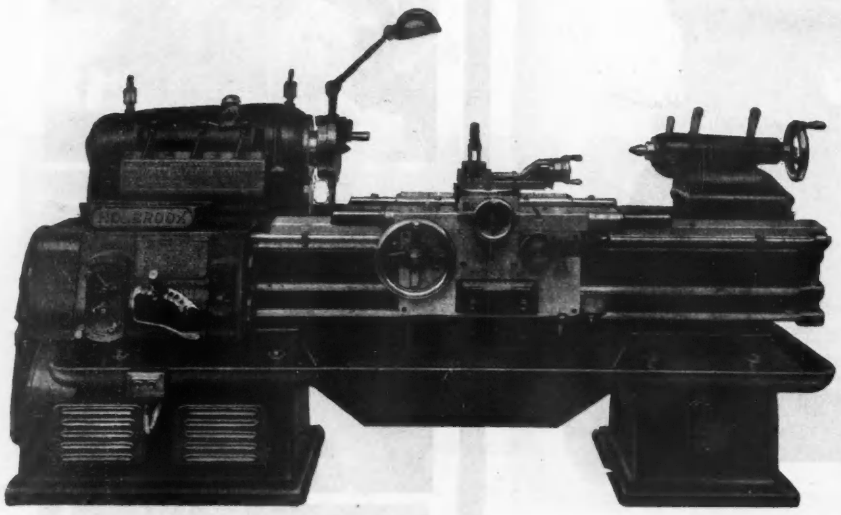

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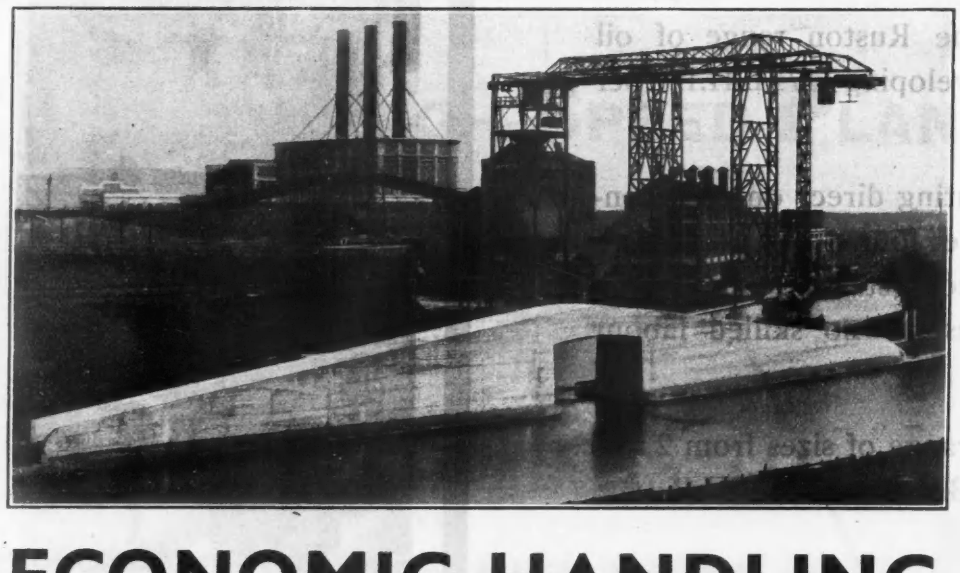

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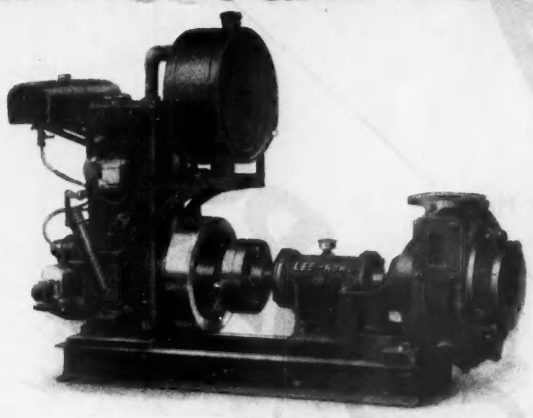

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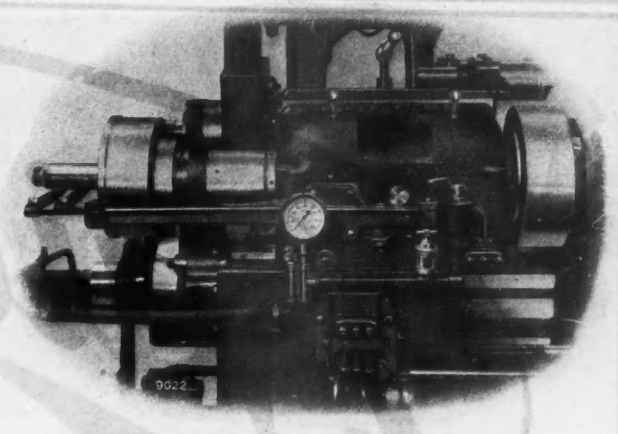

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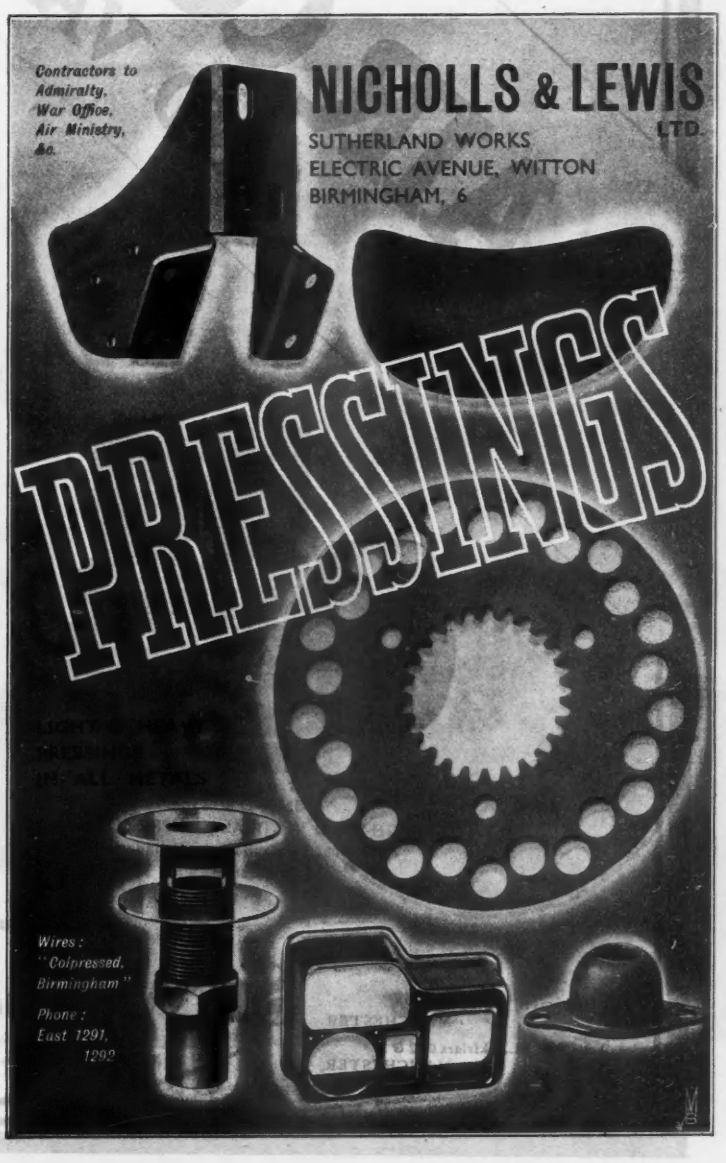

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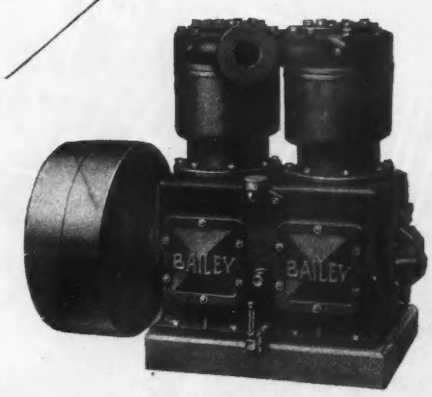

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HIGH-SPEED VERTICAL COMPRESSOR.
With One, Two and Three Cylinders,
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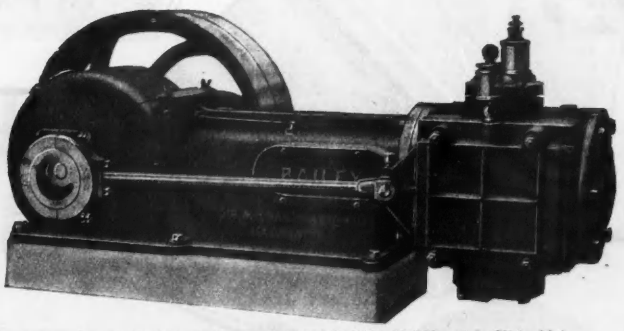

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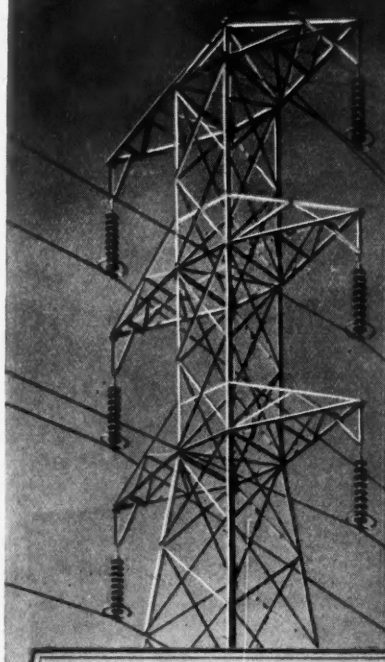
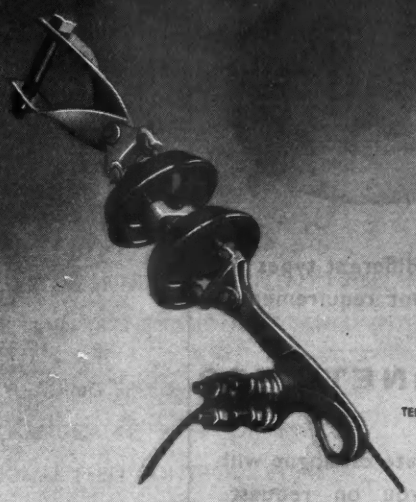
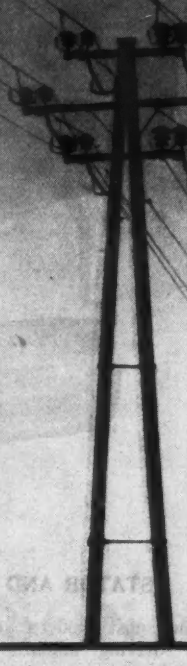




HEWLETT TENSIONING SET



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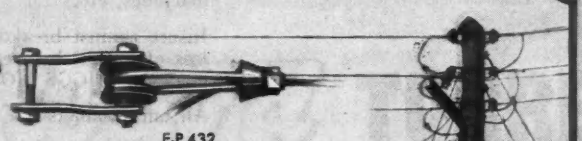

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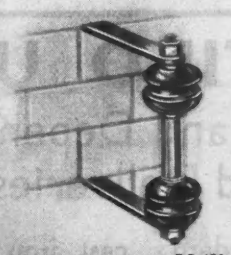

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E.9394 10,000 lb. U.B.S.
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Shunting Cranes

This illustration shows a Diesel Shunting Grabbing Crane constructed to lift :—

3 tons at 16 ft. radius, and to handle a sugar beet Grab at 25 feet radius.

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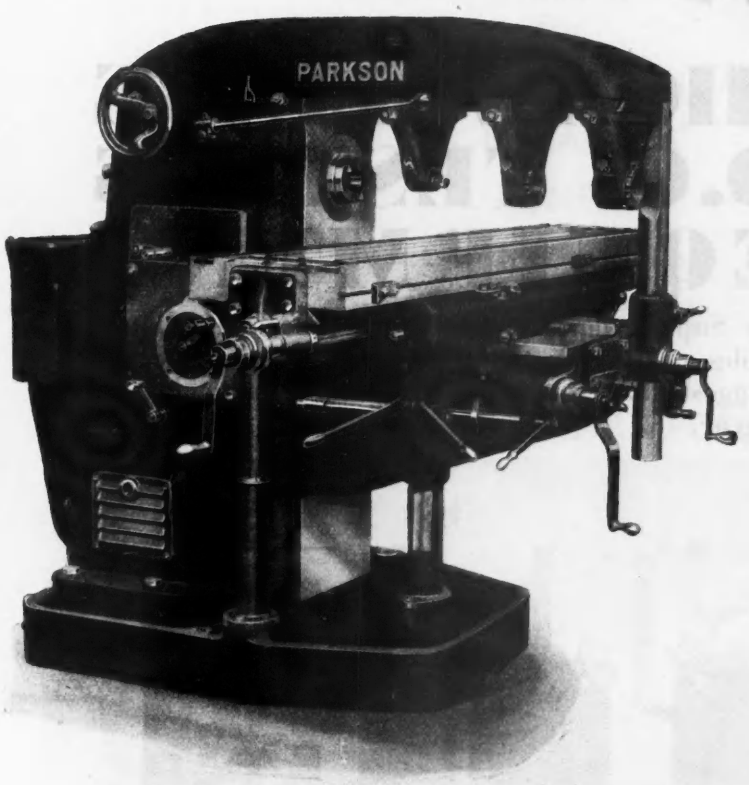

NEW MODEL 3 J.

CAPACITY - 40" x 12" x 18"

TABLE MEASURES 70" x 16½"

FEATURES.

- NITRIDED STEEL SPINDLE MOUNTED ON ROLLER BEARING.
- GEARS IN MAIN TRANSMISSION HARDENED WITH GROUND TEETH.
- DIRECT READING SPEED AND FEED DIALS.
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- DIRECTIONAL FEED CONTROL LEVERS.
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- AUTOMATIC LUBRICATION IN MAIN TRANSMISSION AND FEED TRAIN.
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- BUILT TO GUARANTEED LIMITS OF ERROR.

J. PARKINSON & SON, SHIPLEY.

CAPSTAN AND Ward TURRET LATHES

WITH COVERED BEDS

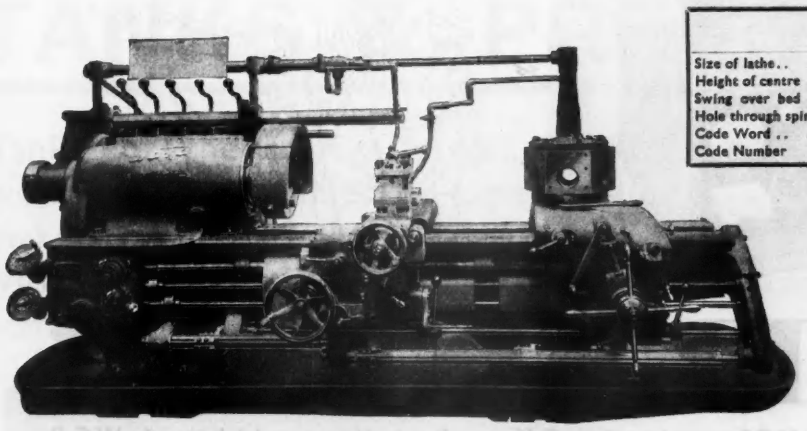

Illustration of a No. 8 size Turret Lathe.

RANGE OF SIZES:

	CAPSTAN LATHE	COMBINATION TURRET LATHES			
Size of lathe	No. 7	No. 7	No. 8	No. 10	No. 13
Height of centre	8⅛in.	8⅛in	10⅛in.	12⅛in.	15⅛in.
Swing over bed covers	16in.	16in.	19½in.	23in.	28in.
Hole through spindle	2⅛in.	2⅛in.	3⅛in.	4⅛in.	7⅛in.
Code Word	COVERLAY	COVERRO	COVERLET	COVENANT	COVERTED
Code Number	13597	13501	13596	13511	13578

SPECIAL FEATURES:

Always Fixed Stainless Steel Bed Covers.

Ball and Roller Bearings throughout Headstock.

Ground Gears throughout Headstock.

Automatic Lubrication to every moving part.

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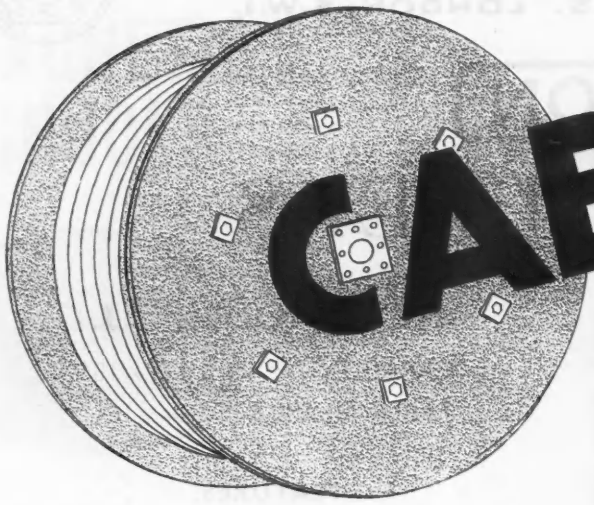
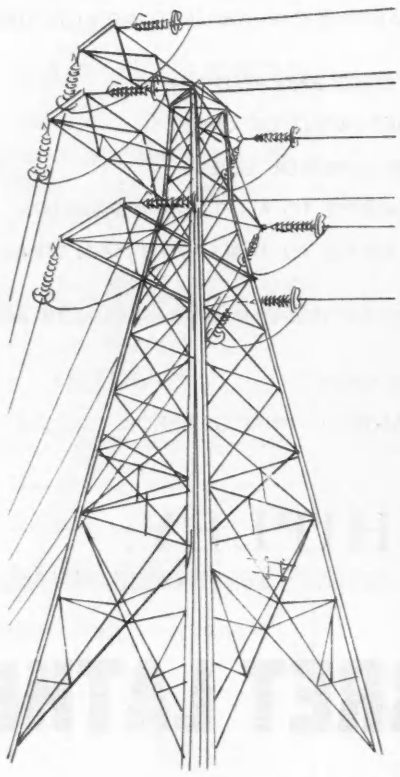
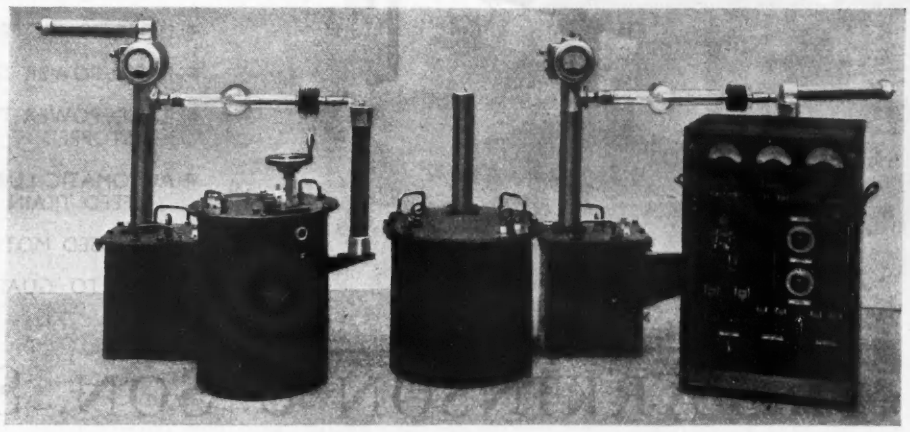


CABLES

HIGH VOLTAGE D.C. TESTING EQUIPMENT



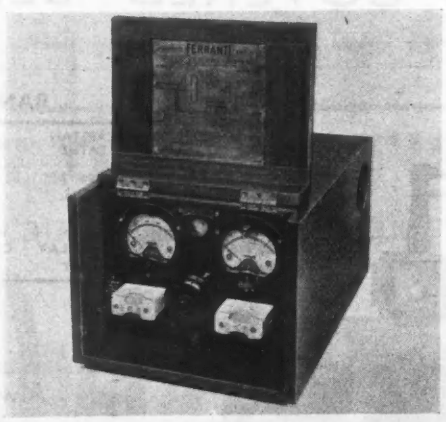
Continuity of your Supply depends largely on the condition and safety of your cables. Regular testing by reliable equipment is essential. We suggest that you write for fullest particulars of Ferranti Testing gear.



STANDARD RANGE UP TO 200 K.V. Mid-Point or one end earthed: power consumption during test reduced to a minimum. Separate units for easy transport. Convenient assembly and connecting up. Test in accordance with Electricity Supply Regulations, 1934. Defective spots and *incipient faults detected before breakdown. Faults can be burned out.* With a high voltage bridge high resistance faults can be located. Periodic tests enable condition of cables to be recorded.

FOR LOW TENSION CABLES 1500 Volts D.C. EQUIPMENT

This equipment can be used on any 50 Cycle supply between 200 and 250 volts. Will pressure test cables with insulation resistance of 30,000 Ohms and upwards.



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PUMPS
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ROAD ROLLERS
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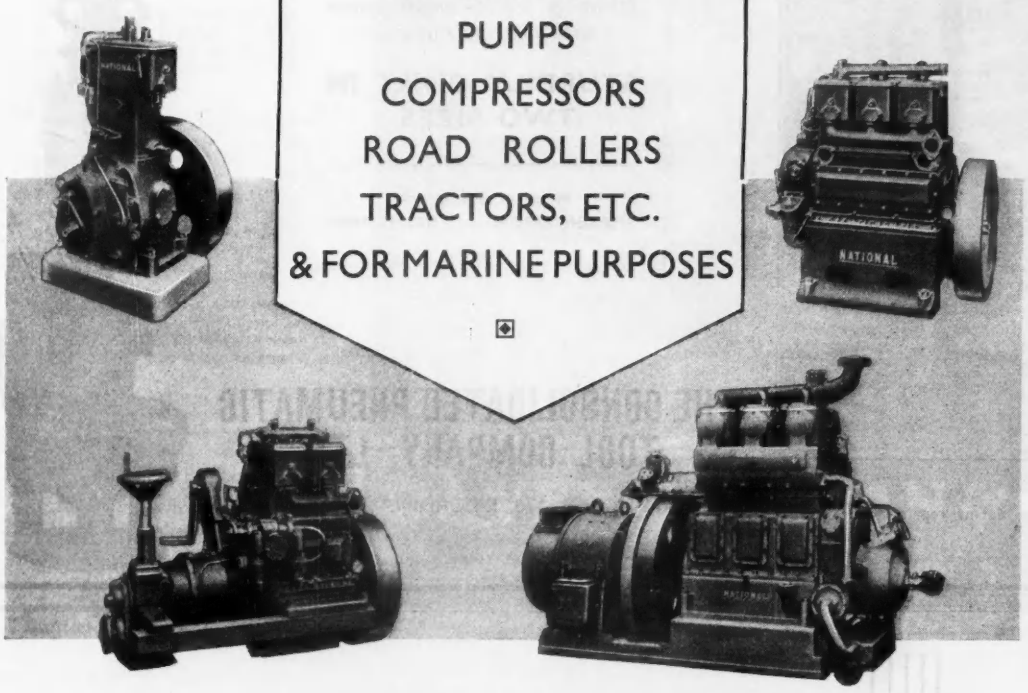
& FOR MARINE PURPOSES



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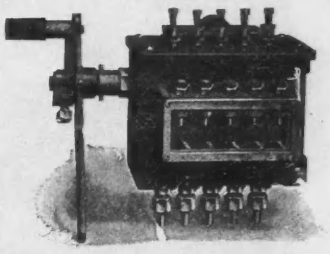
"TWIN-PLUNGER" LUBRICATORS
COMPACT PATTERN
WATERLESS GLASS

MADE IN ANY NUMBER OF FEEDS UP TO TWELVE.



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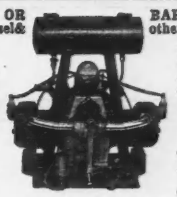

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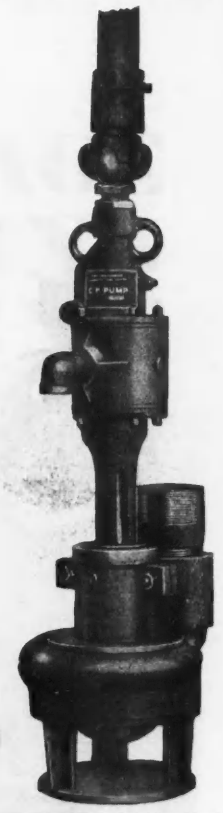

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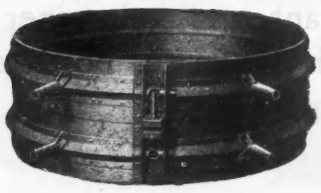

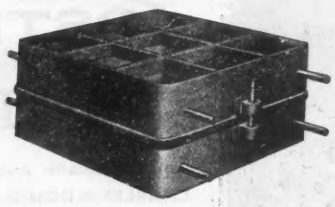

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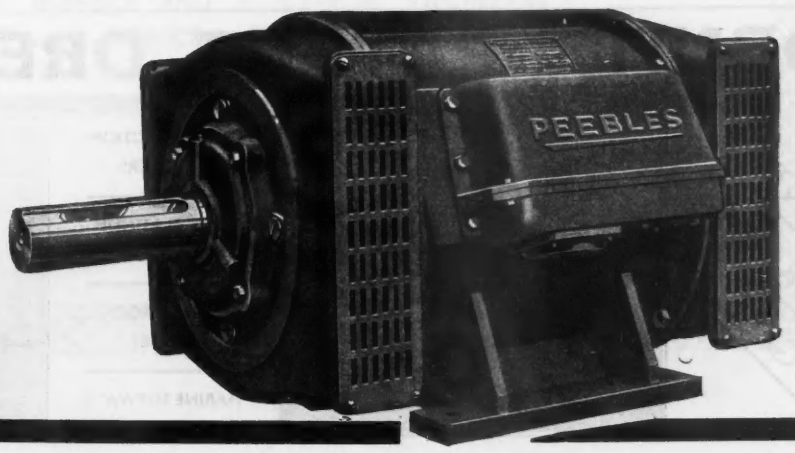

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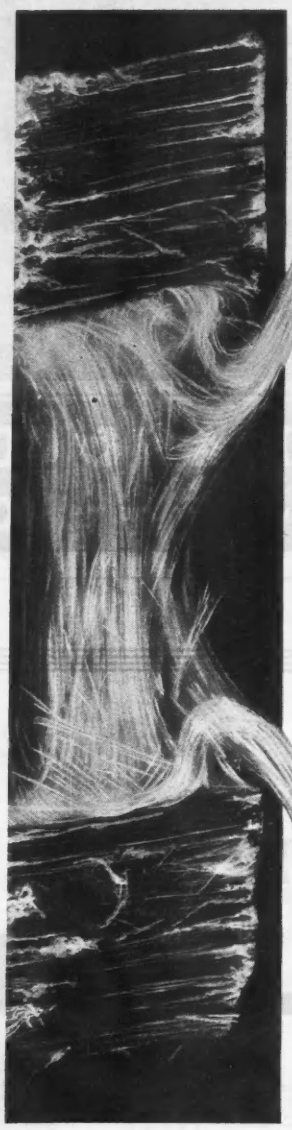
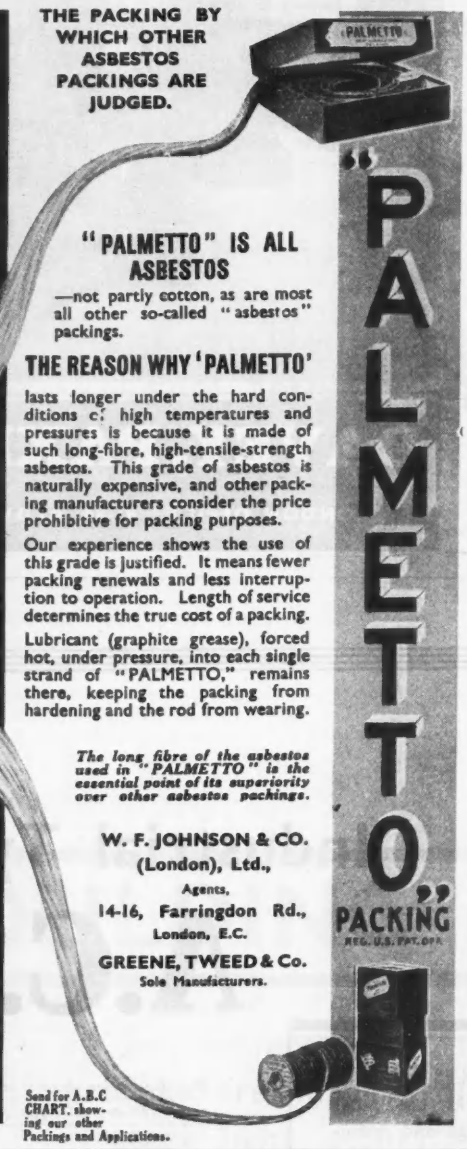


THE PACKING BY WHICH OTHER ASBESTOS PACKINGS ARE JUDGED.



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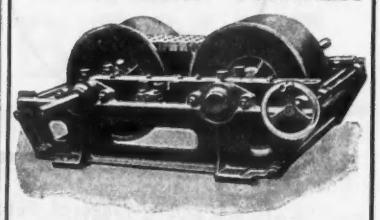

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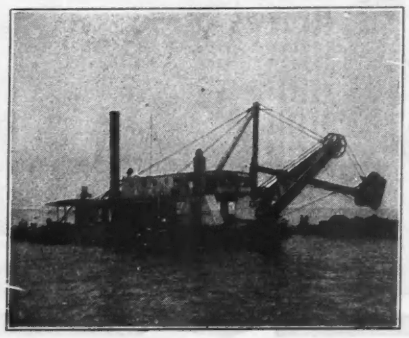

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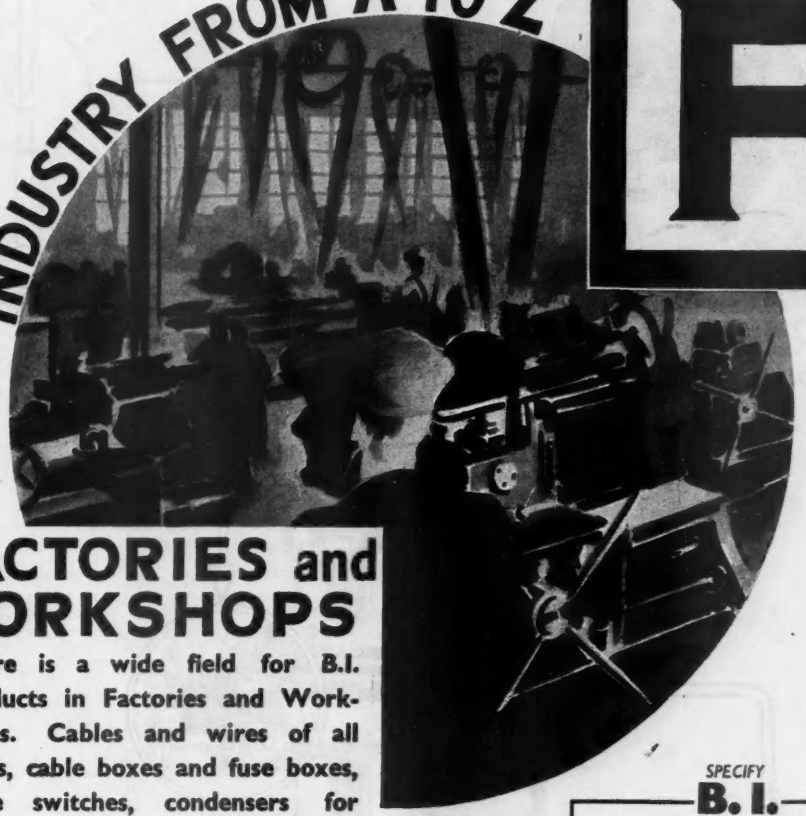

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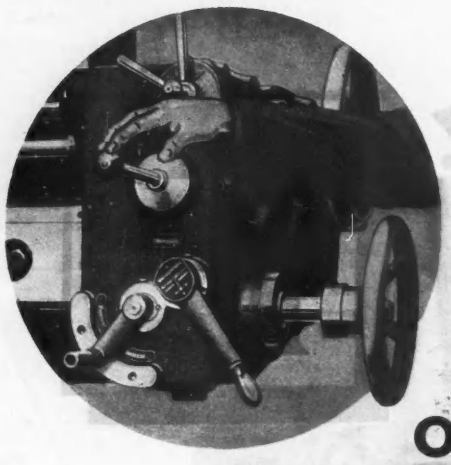
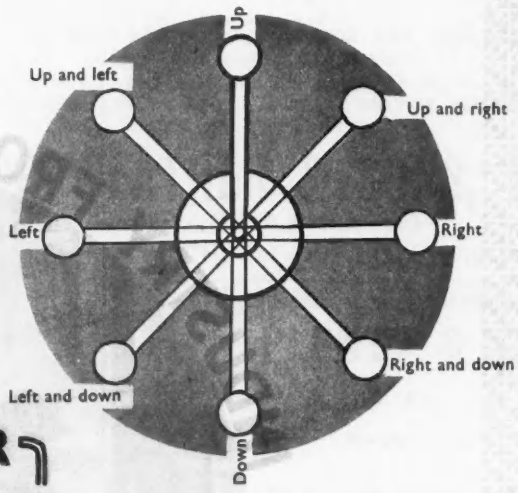
Single Lever Control!

Easy to operate and reducing idle times to a minimum.





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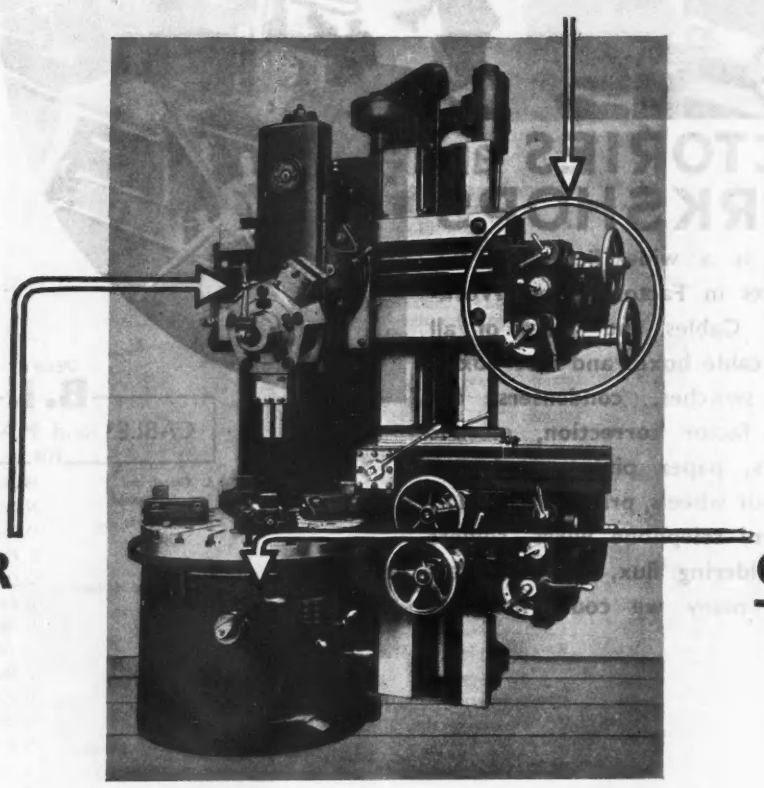
for rapid movements in all directions (Patented)



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ONE LEVER

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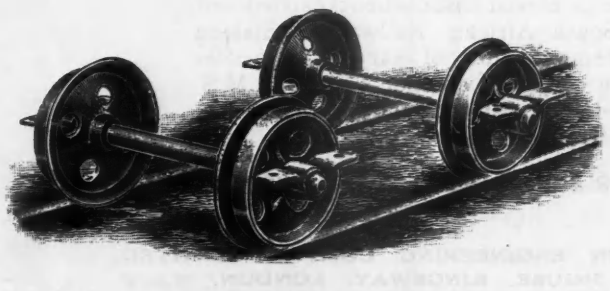

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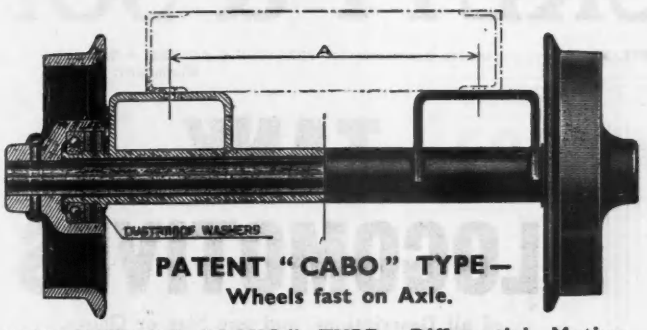
Pressed Steel Casing, Hardened Steel Ball Bearings.



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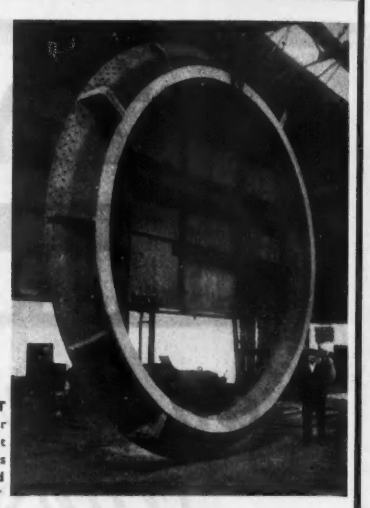

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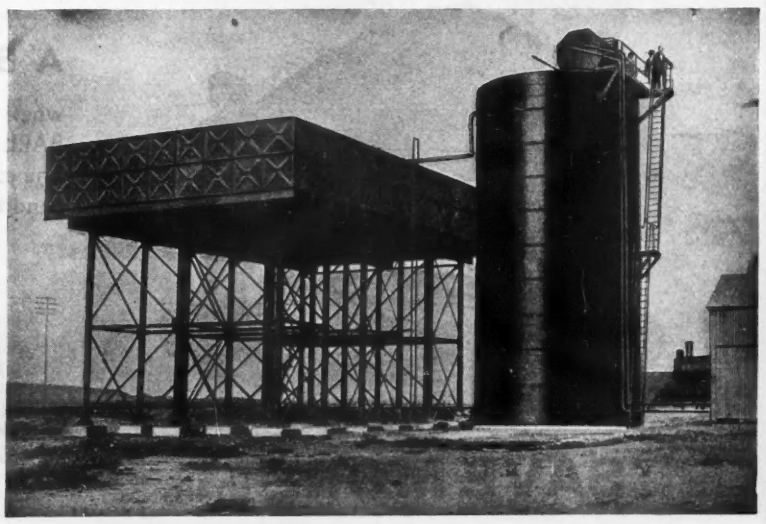

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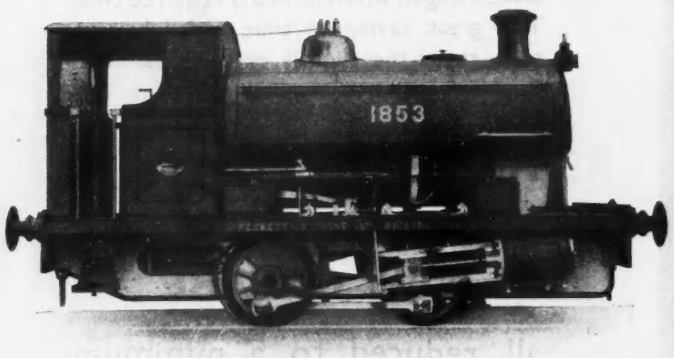

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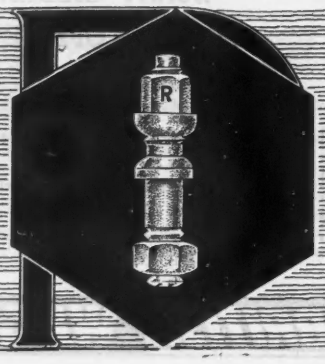

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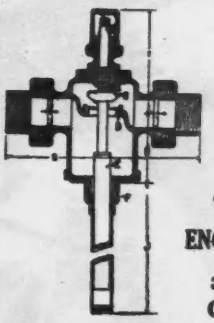
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Yours faithfully,
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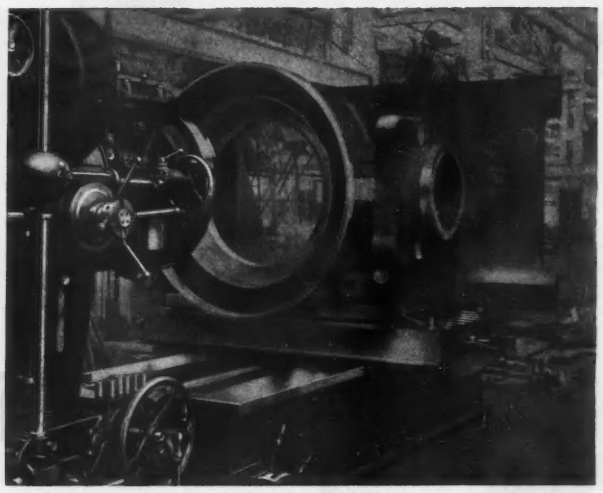

A large Steel Casting for Well Drilling Machinery set up on a No. 5 Kearns Patent Machine. There are several faces to be turned and bored, the largest diameter being 5′ 6″. The job is then rotated through 90°, accurately located by the machine table, and the large side hole is bored. There is also some drilling to be performed.

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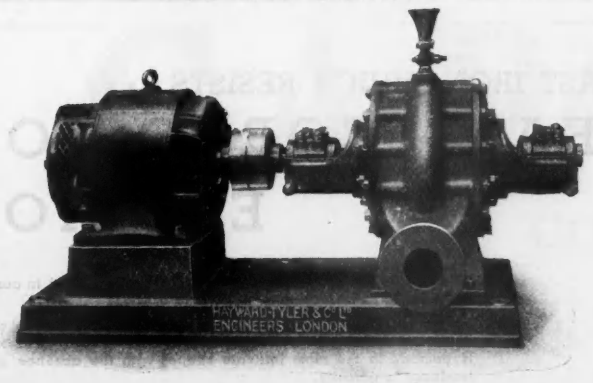

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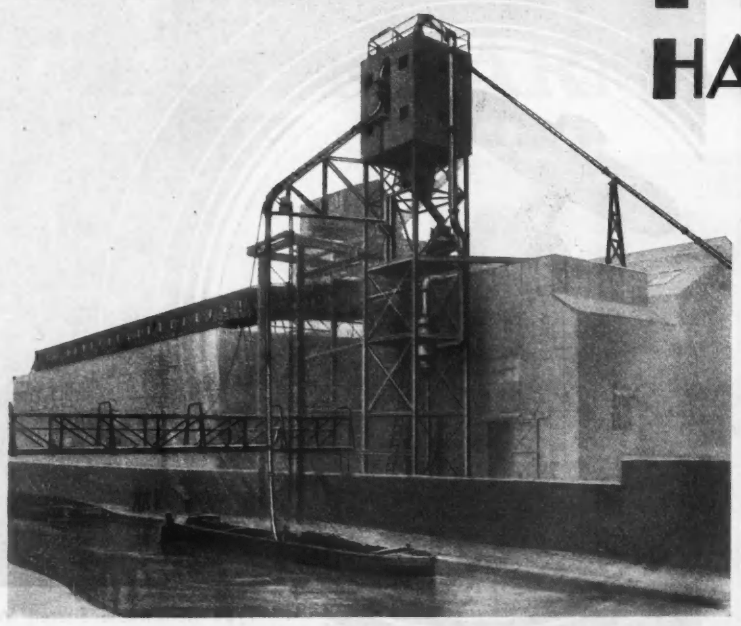

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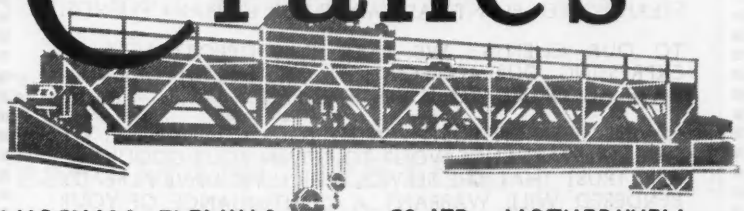

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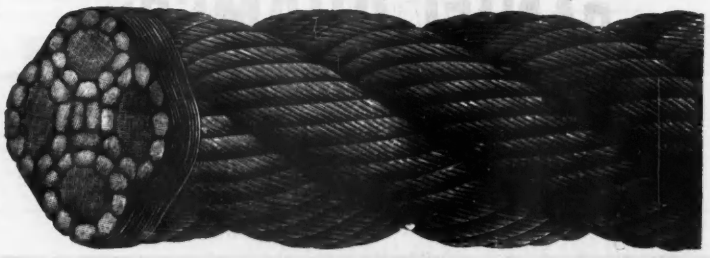

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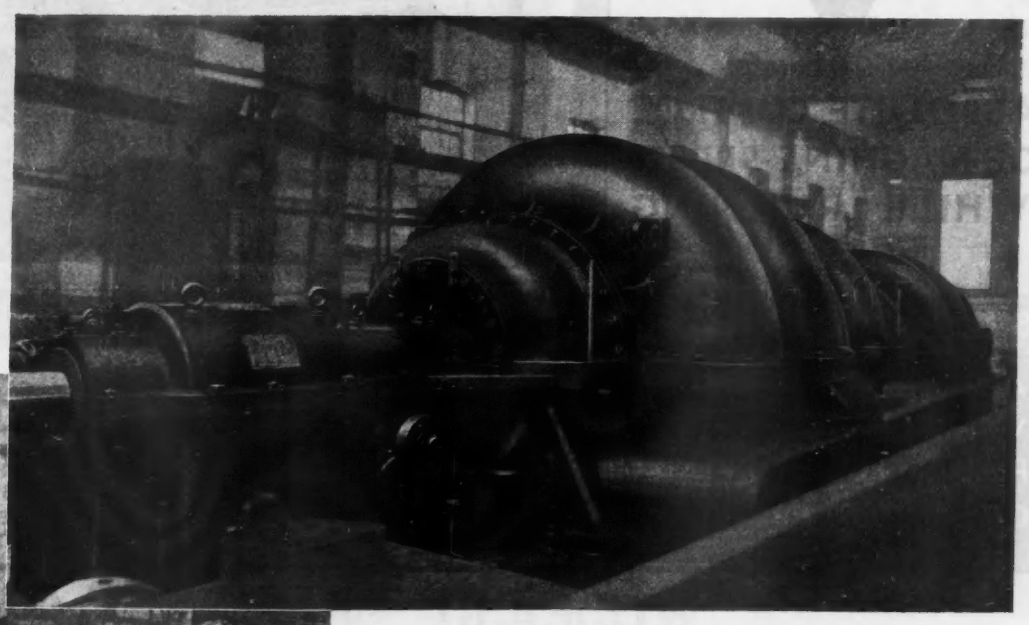
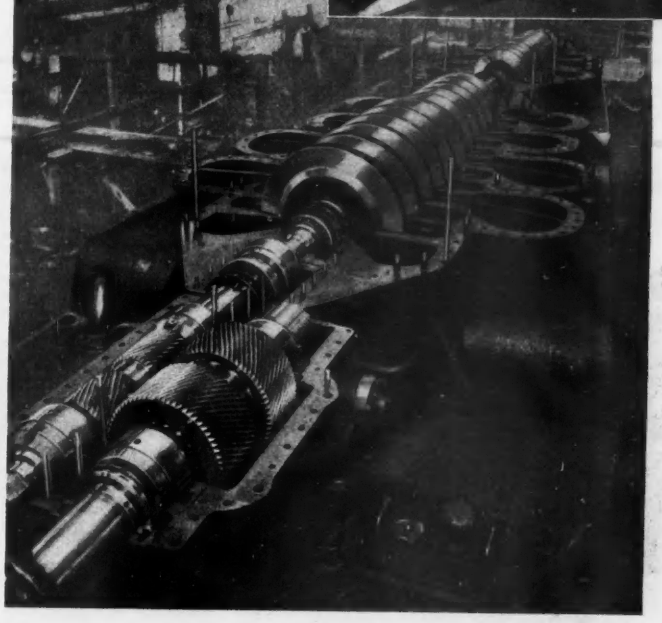


Compressor on Test at Heaton Works



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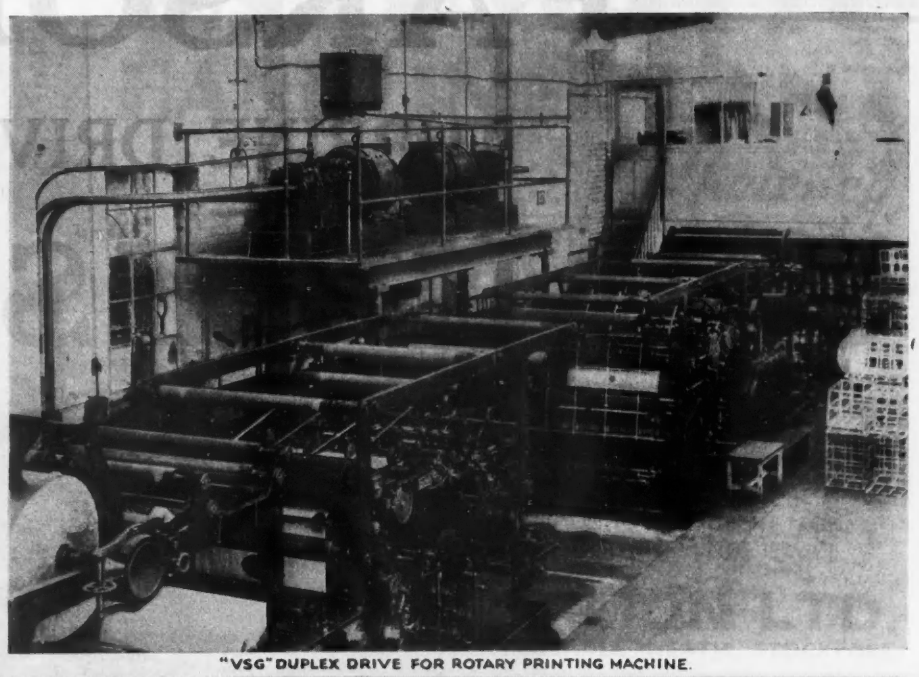

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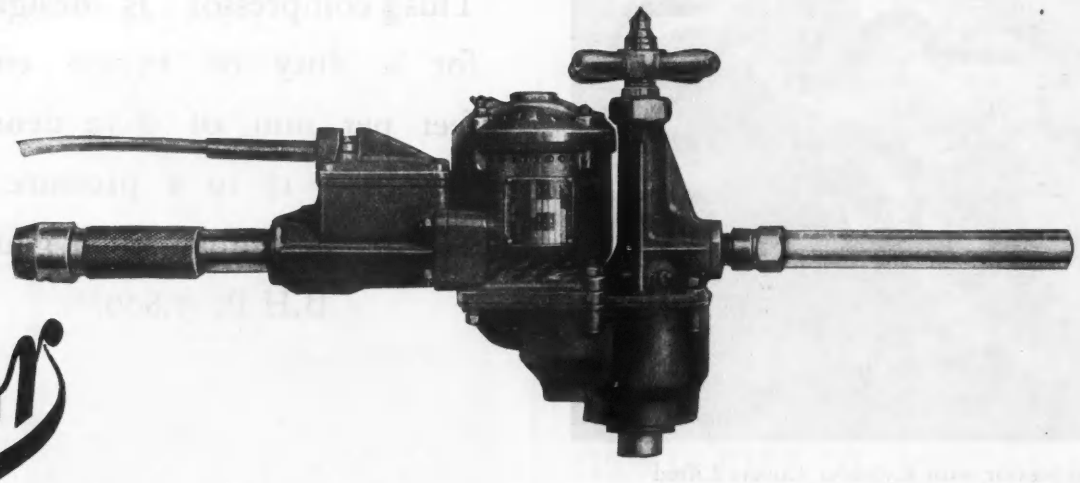

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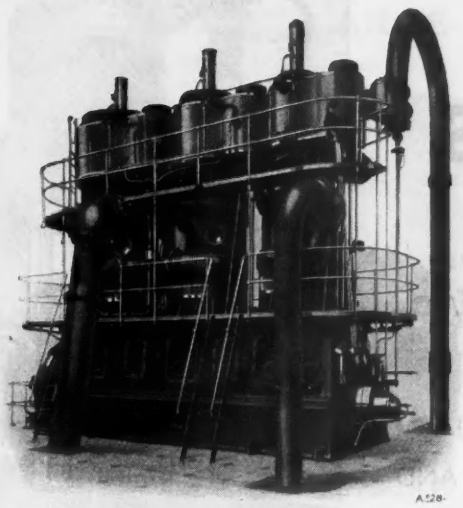

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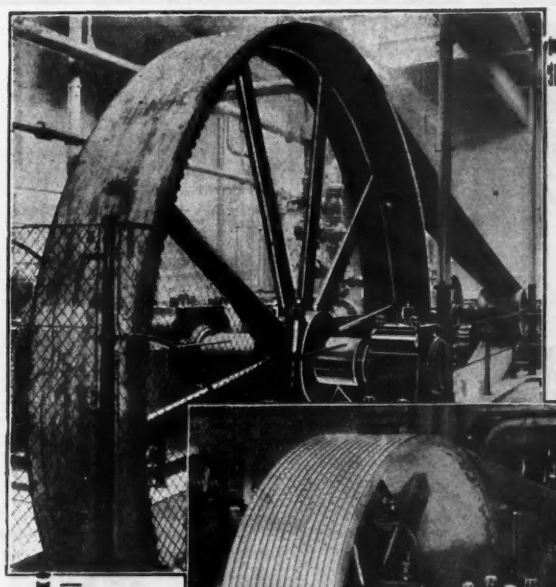

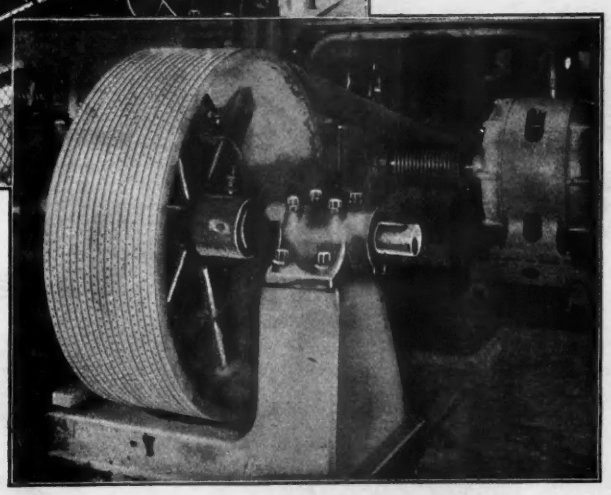

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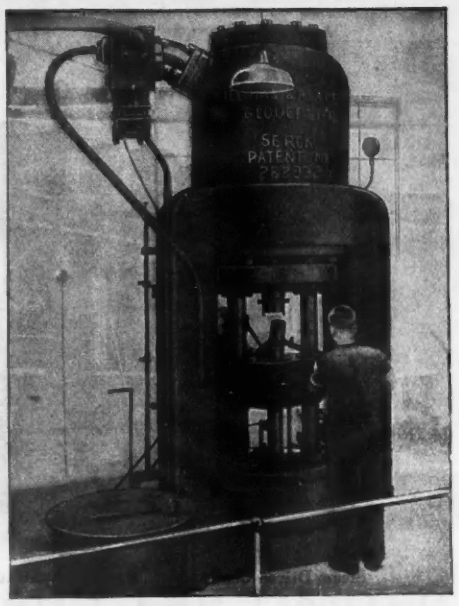

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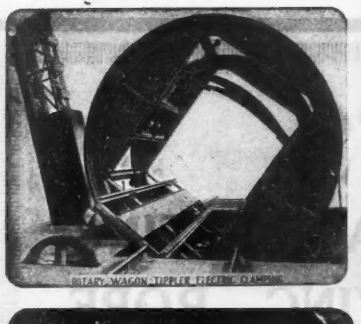

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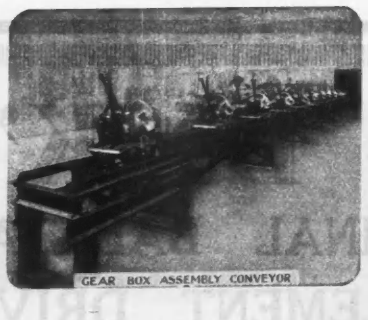

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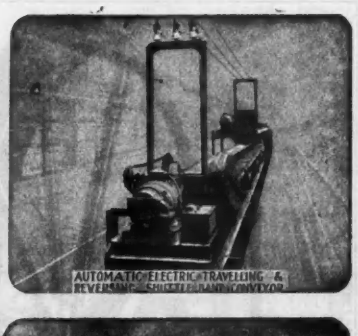

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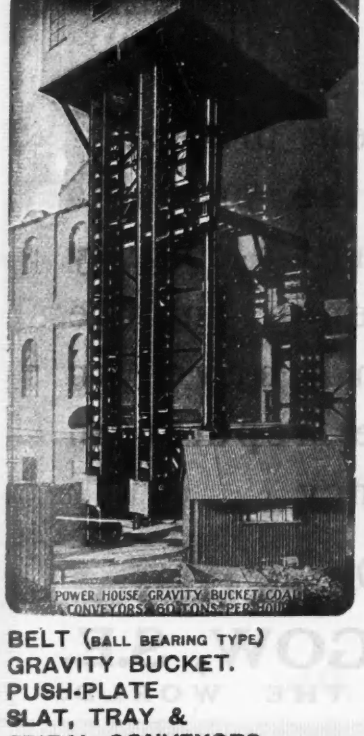

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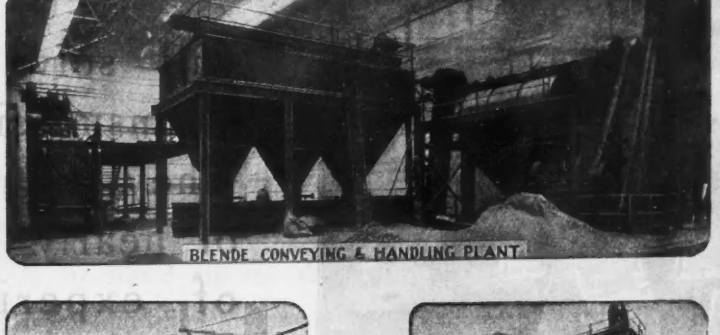

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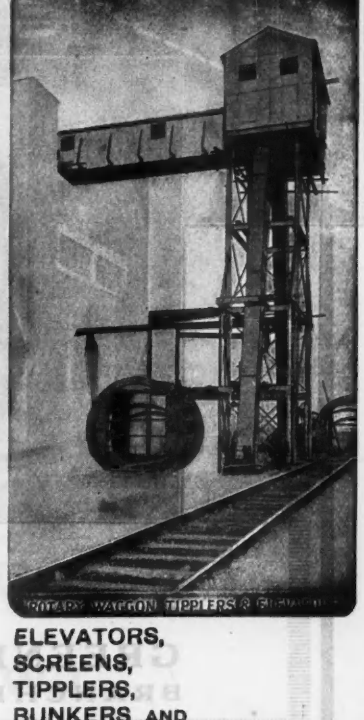

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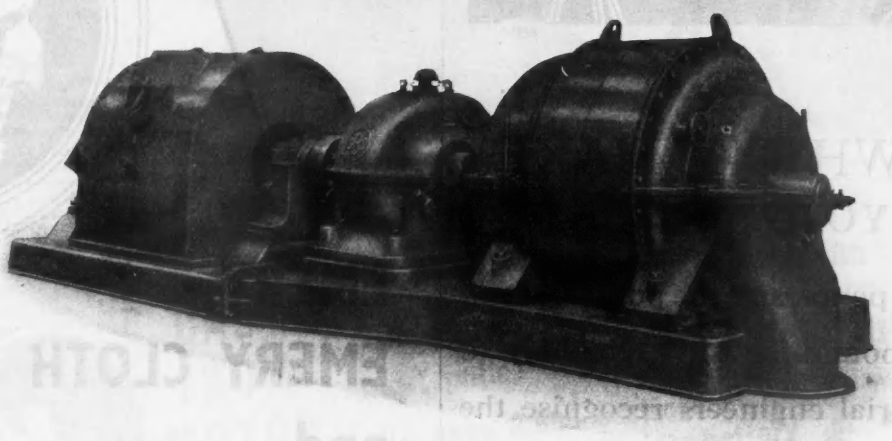

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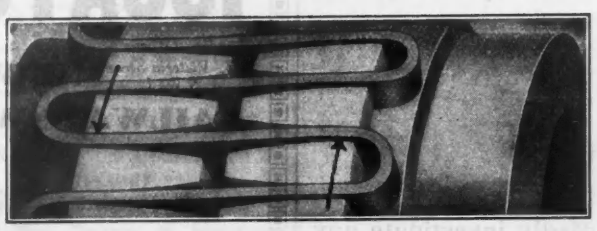

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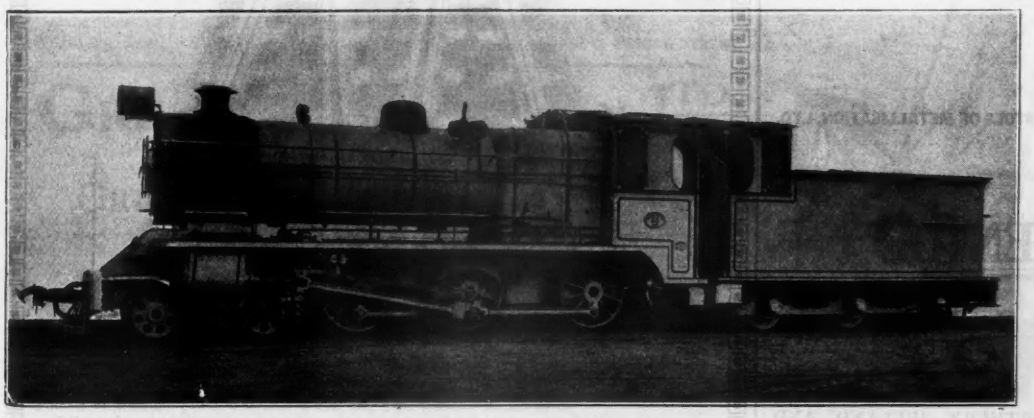

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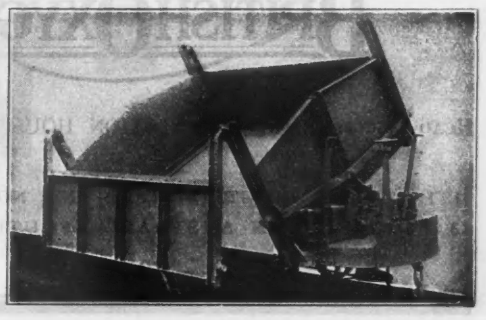

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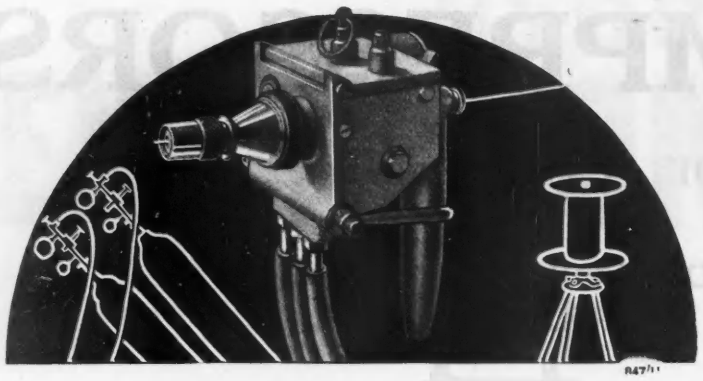

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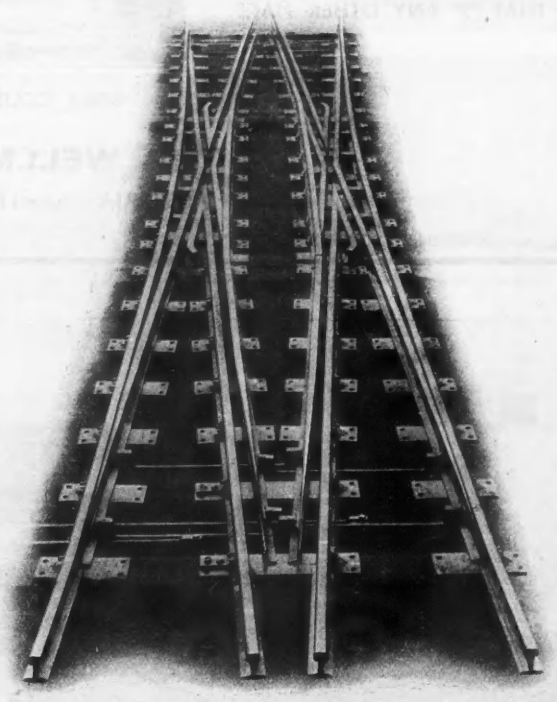

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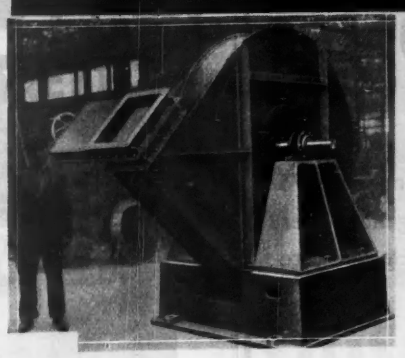

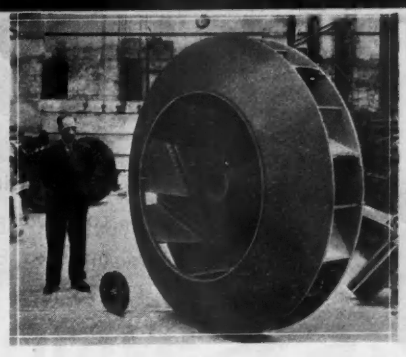

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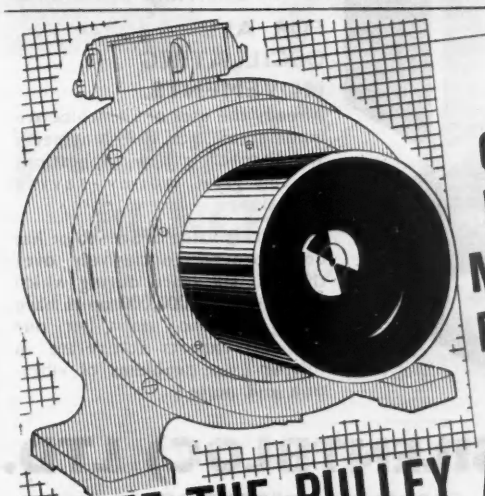

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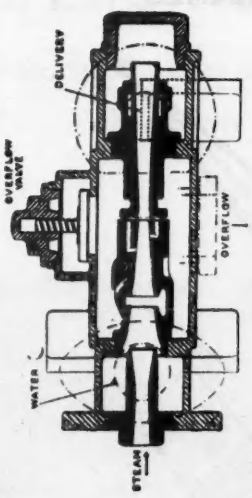

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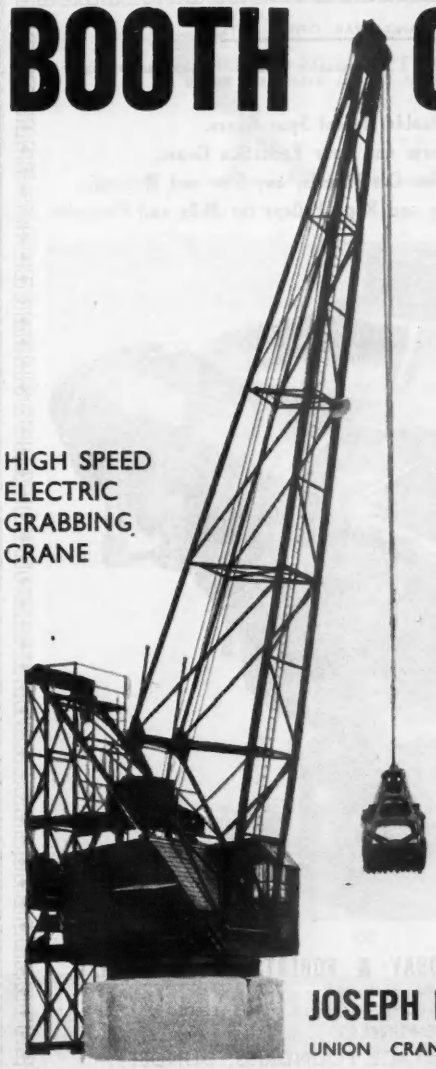

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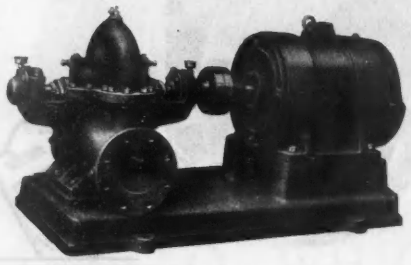

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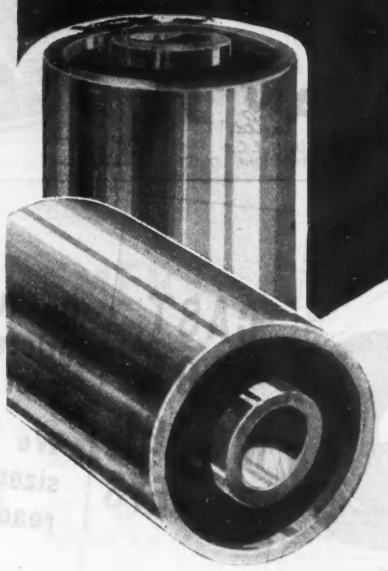

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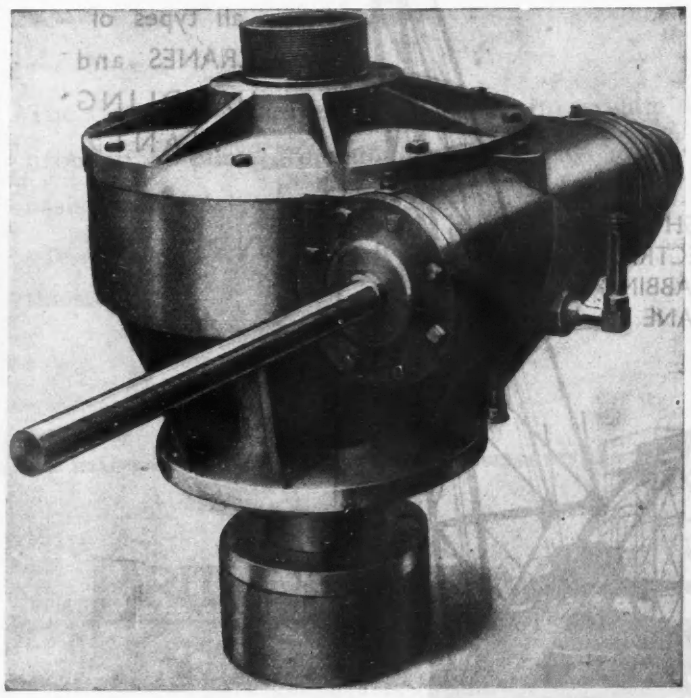

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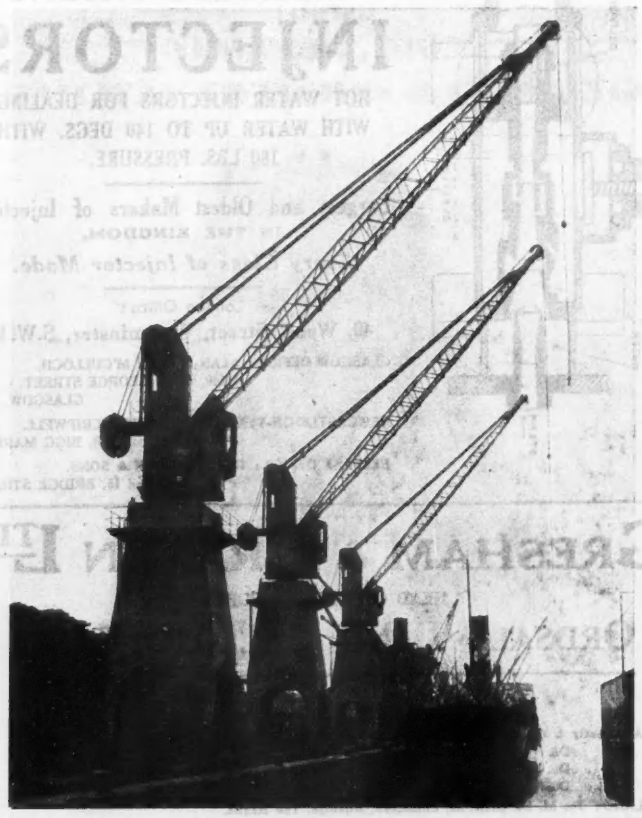

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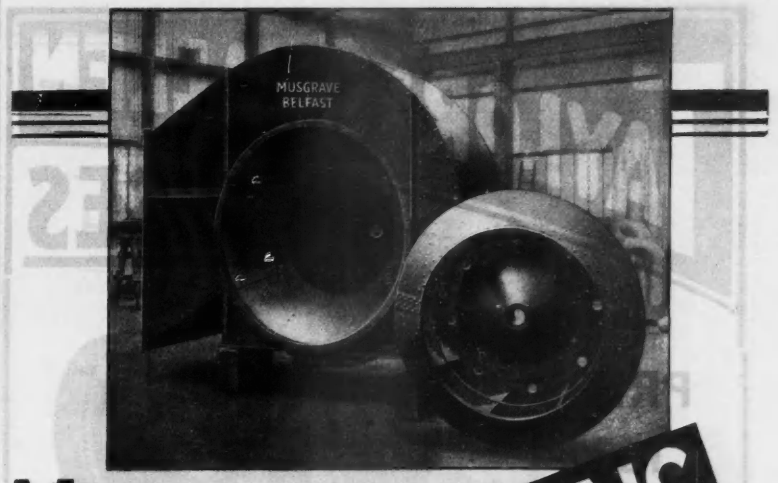

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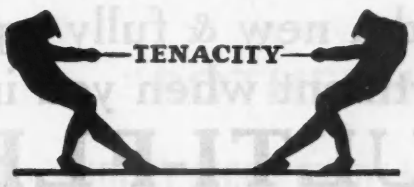

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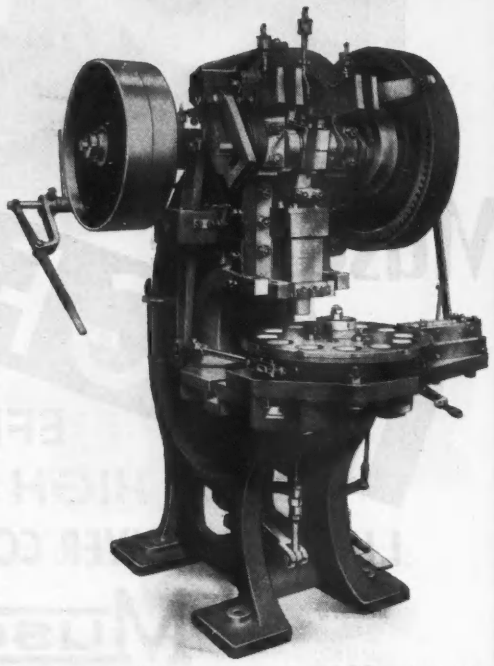

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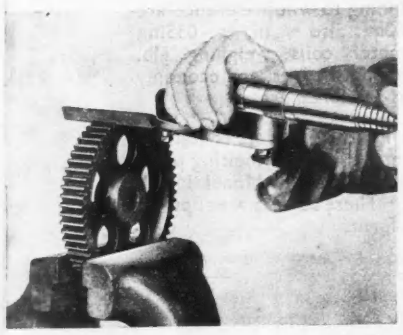

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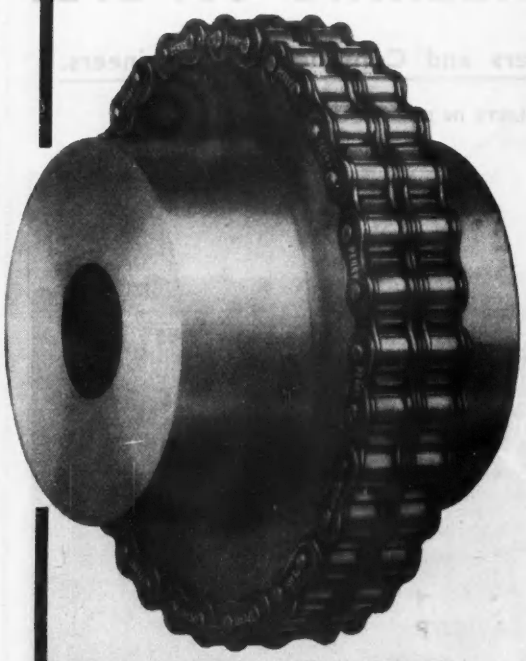

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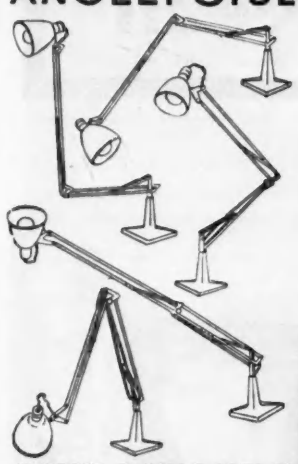

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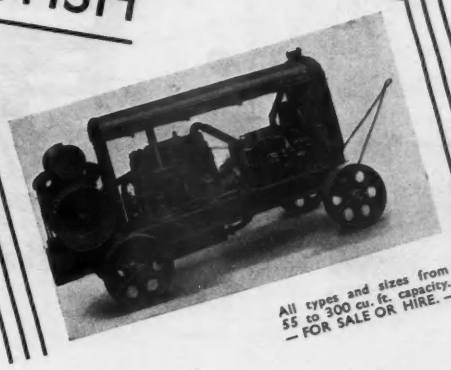

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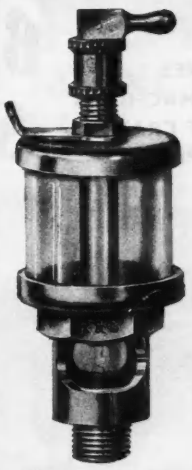

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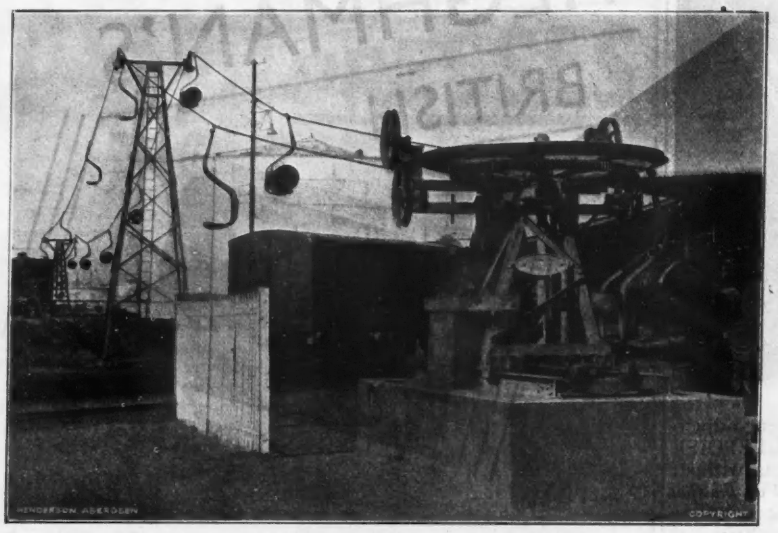

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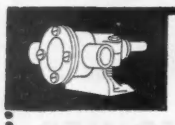

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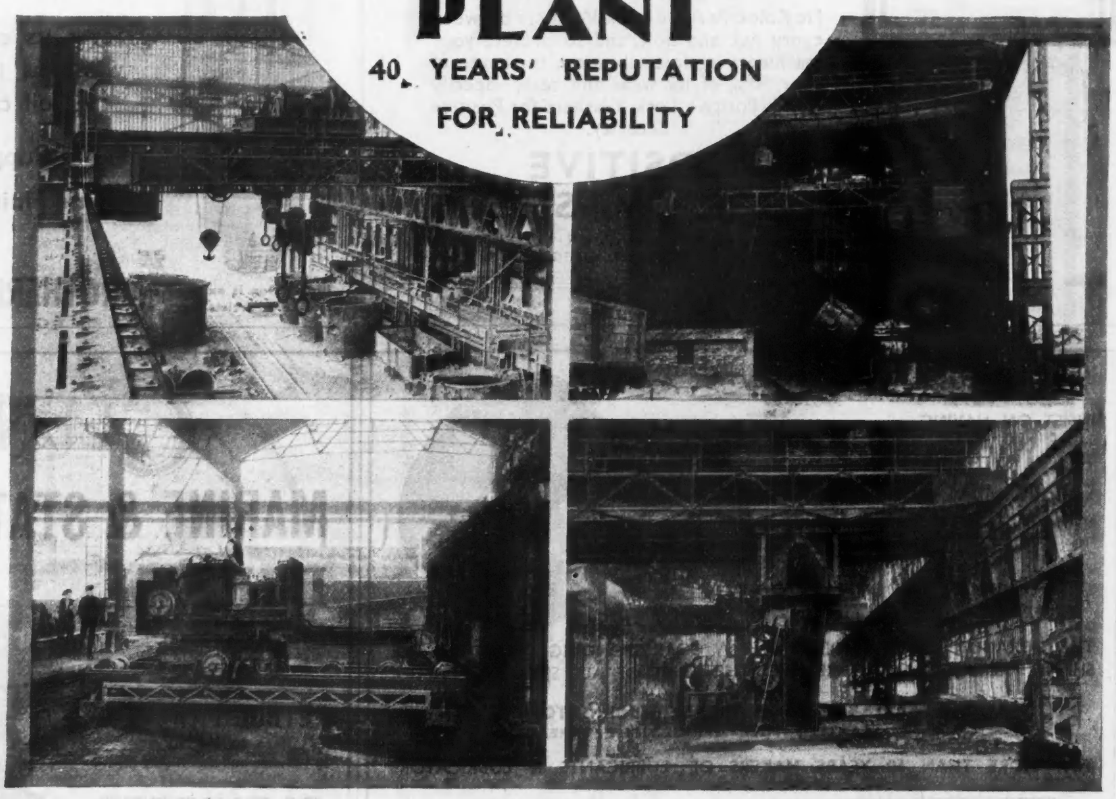

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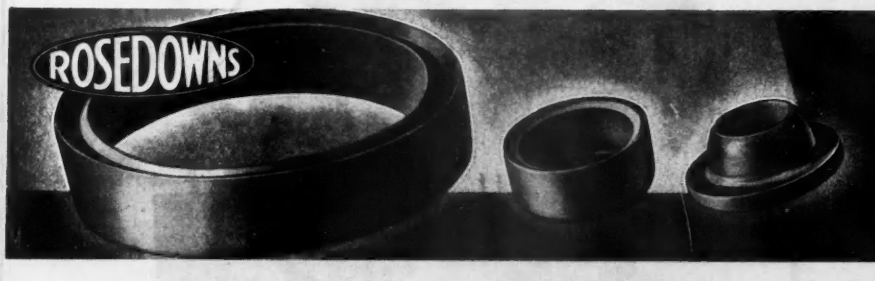

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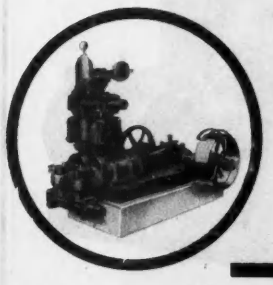
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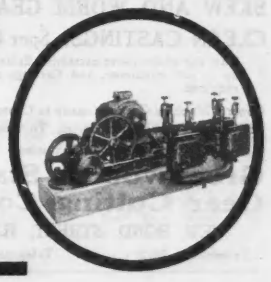

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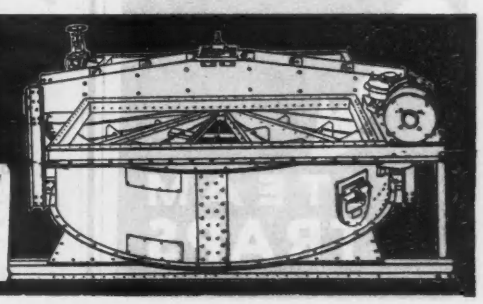

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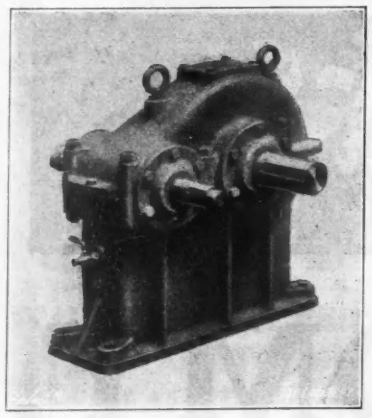

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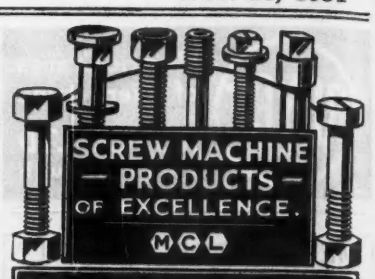

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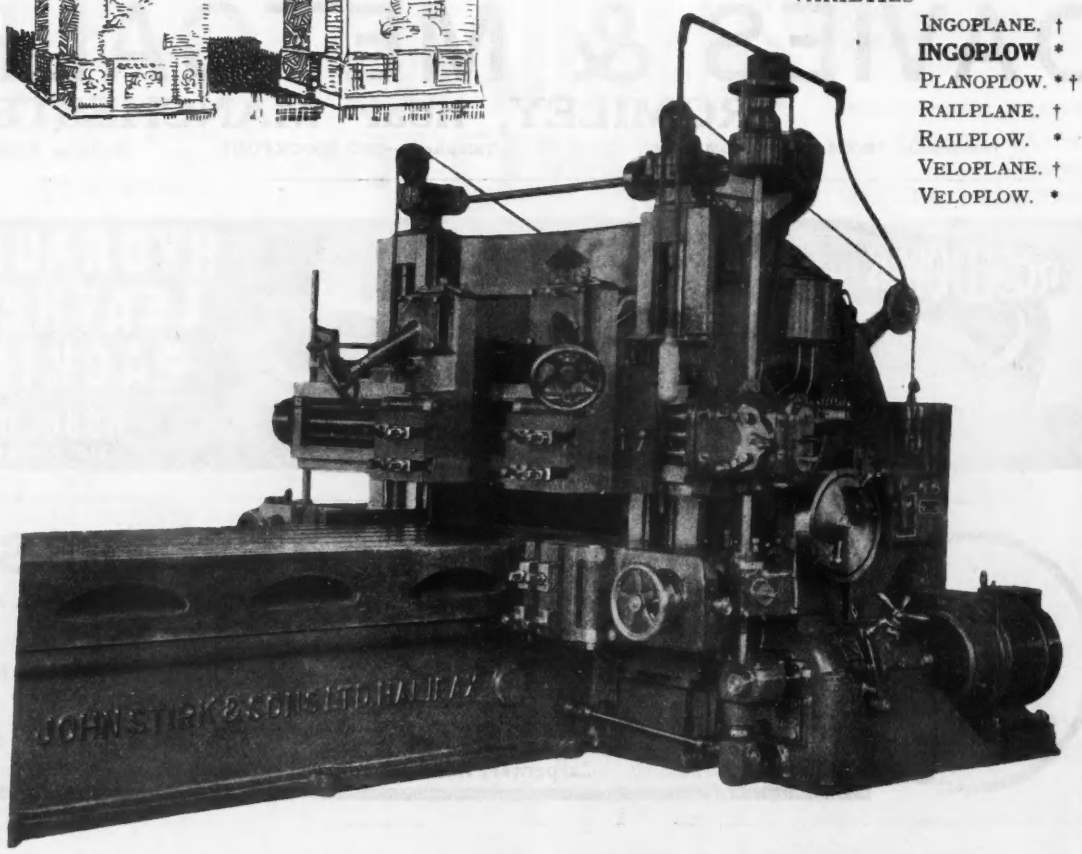

* To plough it off!
† To sail through it!

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for pressures up to
10 TONS
per square inch

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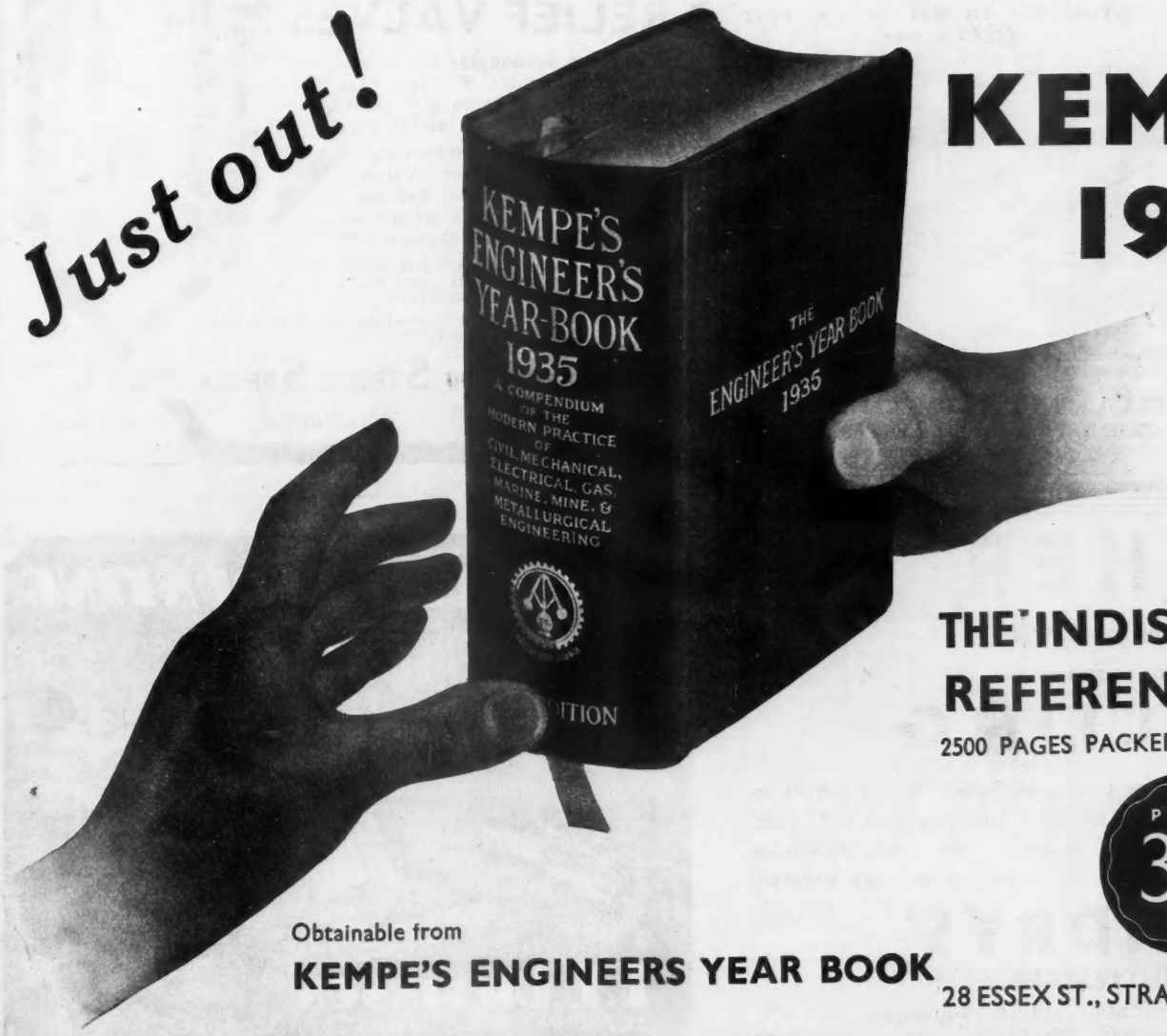

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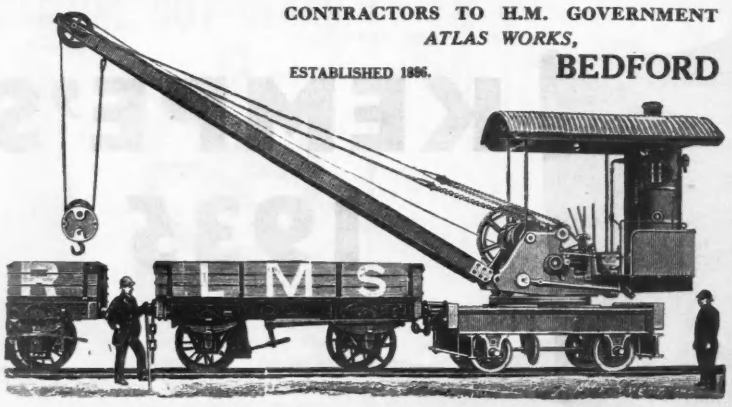

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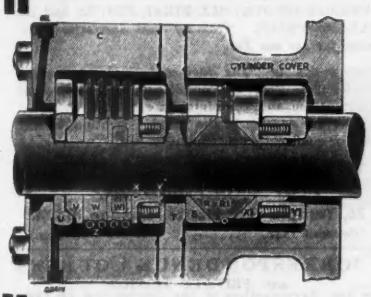

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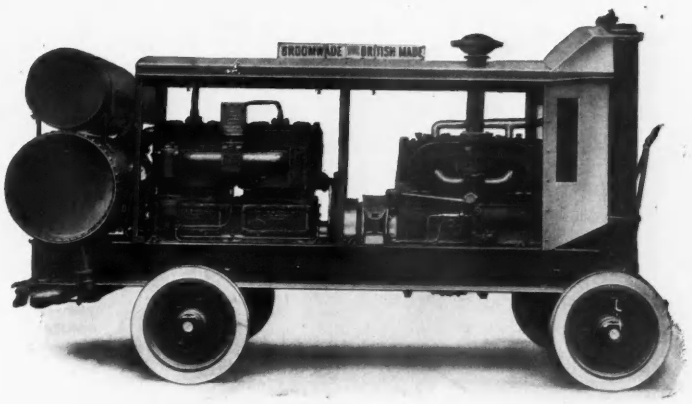

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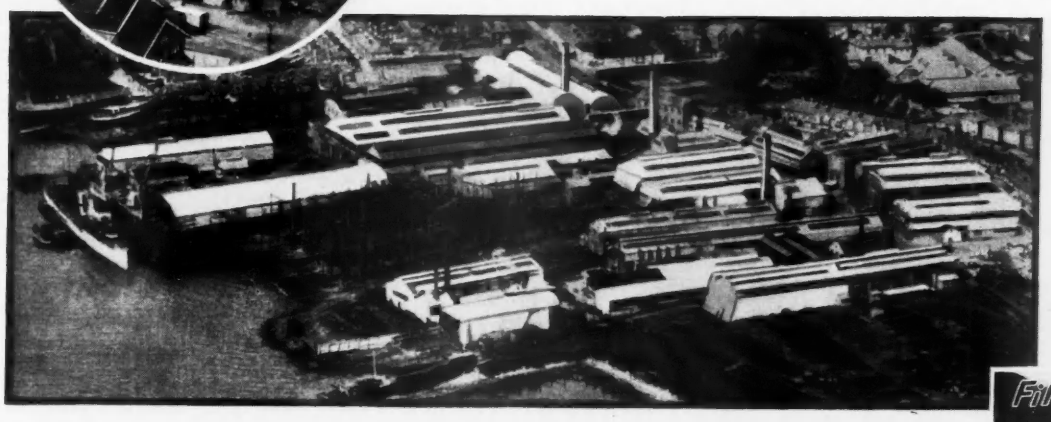

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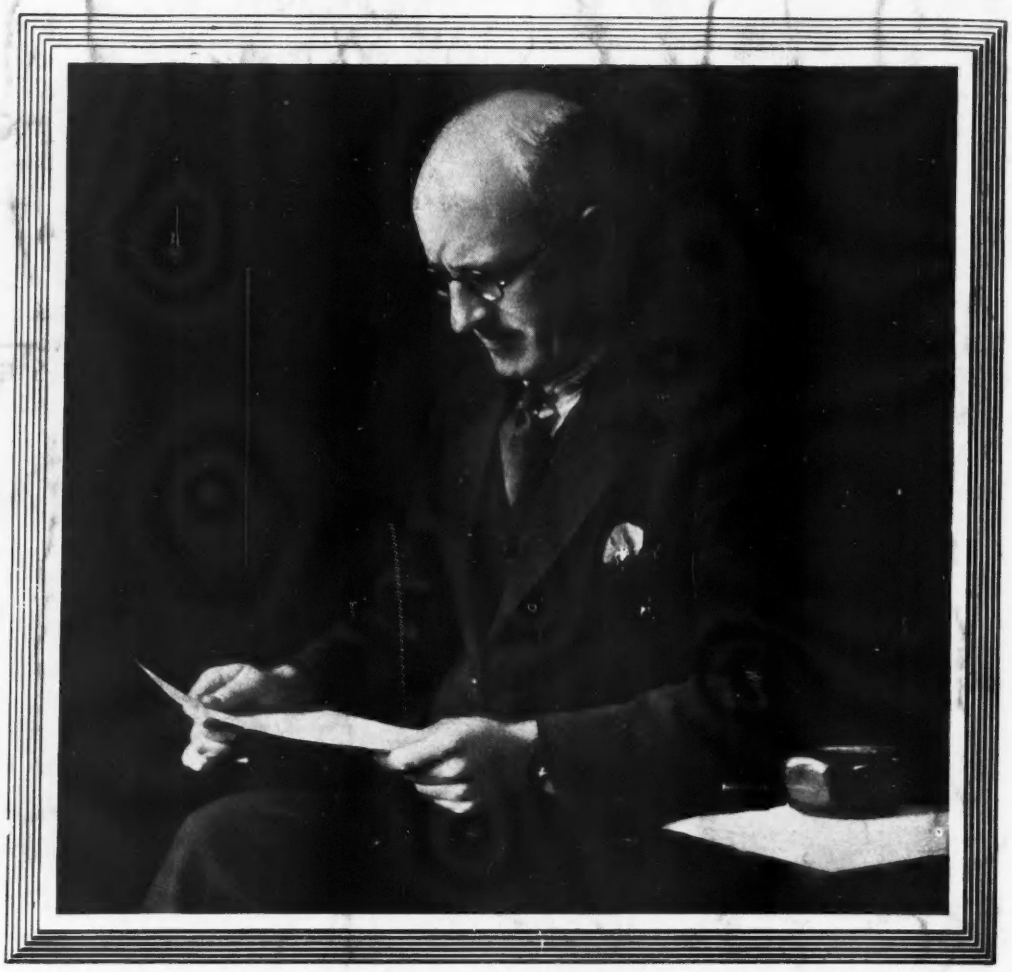

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